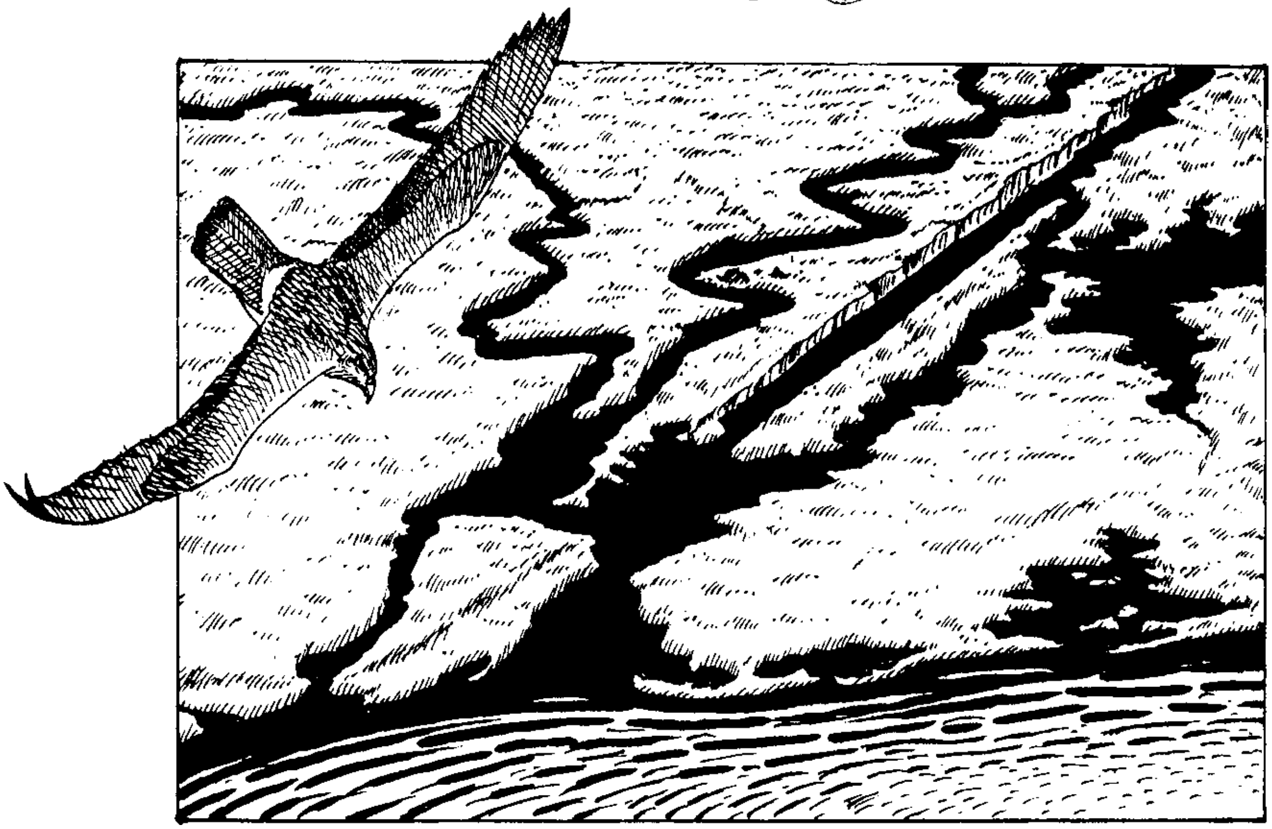
A CLOSER LOOK



SECTION 1

THE NEWARK BAY COMPLEX, *A NATURAL SYSTEM*

The Newark Bay Complex is a series of tidal waterways and open water bays in northeastern New Jersey. Included in the Complex are the lower portions of the Passaic and Hackensack Rivers, which drain into Newark Bay, the Rahway River, the Elizabeth River, the Arthur Kill, and the Kill Van Kull. The headwaters of the Passaic River are in the highlands of northwestern New Jersey, whereas the Hackensack River begins across the state line in New York. Water from the Watchung Mountains and the higher elevations of the Piedmont physiographic region channels into the Rahway and Elizabeth Rivers. These drain to the southeast into the Arthur Kill, which connects Newark Bay with Raritan Bay.

These waters, along with associated wetlands, are affected twice daily by the ocean's tides. They are rich and diverse ecosystems that contain a variety of plants and are used by countless numbers of animals. Although biologists conclude that estuaries are some of the most productive environments on earth, many estuarine systems have been and continue to be altered by the human behaviors of draining, channeling, filling, and dredging.

Estuarine wetlands follow the line of coastal tidal waters. New Jersey contains approximately 325 square miles of tidal land, which includes salt marshes and brackish waters. About 138 square miles are located along the Delaware Bay and River, while another 170 miles edges the southern Atlantic coast. The remaining 17 or so square miles extends from Raritan Bay north into Bergen and Hudson counties.[1] This last portion is included in the Newark Bay Complex.

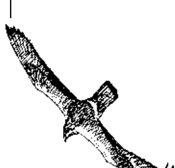
As an ecosystem, the estuary has many functions. It creates an ecotone, or an overlap between freshwater habitats and the ocean. Nutrient-rich sediments from rivers are carried to the estuary where they mix with tidal and ocean sediments. This "nutrient soup" creates the basis for a complex food web upon which many animals depend. Plants and animals that live in the salt marsh habitat must be able to tolerate elevated salinity levels and be capable of surviving fluctuating water levels. Being broad and fairly shallow, estuaries slow both river-induced and ocean-induced floodwaters. They act also as water filtration systems, as well as natural erosion control.

An estuary's expanse and relative shallowness, complimented by deeper channels, provide excellent habitat for aquatic creatures to spawn, lay eggs and for young animals to mature in relative safety. Higher elevation areas in the salt marsh provide tangles of dense grasses and reeds in which mammals and birds can hide and raise their young. Likewise, all these areas provide resting and feeding spots for migrant birds such as shorebirds, waterfowl and raptors.

The estuary is also part of a larger watershed system. A watershed or drainage basin is an area of land that is drained by a specific waterway. The Newark Bay Complex is the lower part of two major drainage basins (Passaic/Hackensack and Raritan) that includes 16 watersheds and many sub-watersheds. All of these watersheds are separated from each other by high relief (ridges, mountains, etc.). Even though the Complex includes only the saltwater or brackish waters of these waterways, it is influenced by the continuous introduction of freshwater from the upstream portion of the drainage basin. Anything that goes into a tributary or main channel flows downstream to be deposited in the estuary or adjacent salt marsh. Since the area of study drains the land where close to two-thirds of New Jersey's population lives, there is a tremendous amount of pressure on these waterways and their adjacent habitats.

The lessons that follow cover basic natural history concepts regarding the function of the estuary including the importance of estuary mud; how animals and plants interact to create complex food webs; how toxins affect the health of the ecosystem; and, where the estuary fits into the regional watershed system. All of these lessons enable students to learn more about their connection with this unique area.

[1] Collins, Beryl Robichaud and Karl H. Anderson. Plant Communities of New Jersey: A Study in Landscape Diversity. Rutgers University Press, New Brunswick, NJ. 1994.



DETRITUS "ITIS"

BACKGROUND INFORMATION

Inorganic material (sand, clay and silt) and organic matter or detritus (bits and pieces of dead vegetation and decaying animals) combine to produce the mud that is an integral part of the estuary ecosystem, the world's most productive biological system. Scientists estimate that a single acre of salt marsh can produce more than 60 pounds of nutrients per day, making it more productive than any land-based acreage.

The inorganic materials carried by ocean tides and freshwater rivers supply important minerals to the system. Most of these particles settle out of the water column in calmer waters such as bays, estuary channels with slow-moving water, and coves. They also get caught in the roots of the extensive marsh vegetation. Detritus provides organic matter from which animals and plants extract nutrients. These nutrients are recycled through the food web as animals and plants live out their life cycles.

In the salt marsh habitat, decaying plants, especially Spartina grasses, are more nutrient-rich than living plant tissue. Microbes break down the dead plant material into tiny manageable pieces that become available for scavengers such as blue claw crabs, mussels, clams and oysters. Though plants produce the energy that drives all food webs, detritus is the driving force behind estuarine food webs. In many estuarine food webs, humans are the highest consumers.

Many different types of pollutants enter the estuary ecosystem. Some of the most persistent and highly toxic of these are a group of man-made organic chemicals that include PCBs and dioxins. PCBs (polychlorinated biphenyls) were used widely as coolants and lubricants in electrical equipment such as transformers and capacitors. The manufacture of PCBs in the United States was stopped in 1977, but a large quantity of PCBs remains in service. Dioxins are unwanted by-products of many different processes including incineration, production of herbicides and disinfectants, and the production of paper that uses chlorine.

These compounds enter the environment through various means - improper disposal, spills, incineration and direct industrial discharge. They also adhere to suspended particles in the waterway and eventually settle to the bottom along with other bits of detritus. Although they have been diluted by great quantities of water, they remain persistent in the aquatic environment because they break down very slowly.

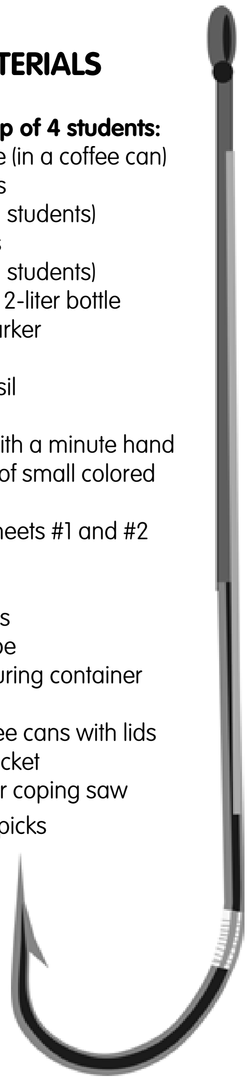
LEVEL
4 to 6

LENGTH
3 class periods

MATERIALS

For each group of 4 students:
- o mud sample (in a coffee can)
- o paper plates (1 for every 2 students)
- o hand lenses (1 for every 2 students)
- o clear plastic 2-liter bottle
- o indelible marker
- o spoon
- o mixing utensil
- o ruler
- o timepiece with a minute hand
- o tablespoon of small colored beads
- o Discovery Sheets #1 and #2

For the class:
- o paper towels
- o masking tape
- o water in pouring container (1 gallon)
- o several coffee cans with lids
- o clean-up bucket
- o utility knife or coping saw
- o box of toothpicks



OVERVIEW

Students learn about the composition of mud. A simulation shows how sediments and pollutants mix and settle under natural conditions.

OBJECTIVES

Students will:

- Classify the organic matter and inorganic materials found in mud;
- Describe the role of detritus in the estuary ecosystem;
- Observe and describe the mixing and settling of sediments in an estuarine-like setting;
- Explain how some contaminants enter the estuary ecosystem.

ADVISORY LINK

Detritus is the primary component of muddy bottom sediments found in aquatic habitats. Detritus is also the basis of the estuarine food web. Organic chemicals such as PCBs and dioxins become part of the estuarine environment when they adhere to sediment particles. The Fish Consumption Advisories lists fish and crab species that are at risk of concentrating high levels of toxic chemicals in their bodies.

KEYWORDS

contaminant
detritus
dioxins
ecosystem
estuary
inorganic
non-point source pollution
organic
PCBs
point source pollution
sediment

STUDENT PREREQUISITES

A basic understanding of estuary ecology
An understanding of how food chains and food webs work

PROCESS SKILLS

classifying
investigating
experimenting
observing
collecting and recording data
interpreting data
formulating hypotheses
analyzing
measuring
inferring

PLANNING

1. Fill several coffee cans with "bottom mud" from a lake or pond. Drain off the excess water. Keep the mud in a sealed container to prevent drying. **(Do not take mud from the Newark Bay Complex. Contamination from PCBs and dioxins prevents safe handling.)**
2. Prepare sediment-settling containers (one per four students). See Figure 1A.

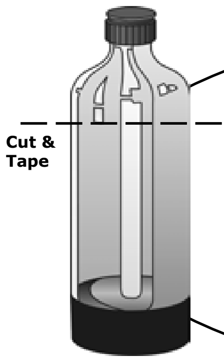
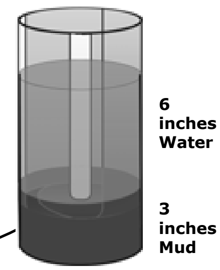


FIGURE 1A

HOW TO PREPARE A SEDIMENT SETTLING CONTAINER

1. Collect clear 2-liter seltzer bottles (1 for each group of 4 students). Remove the colored bases from each.
2. Cut off the tops of bottles using a utility knife or coping saw. Put masking tape on the edge of the container to prevent cuts.



PROCEDURE
SETTING THE STAGE

Discuss experiences that the students have had with mud.
Ask, "Where was it"? "What was it like"? "What were you doing"? "Is all mud alike"?

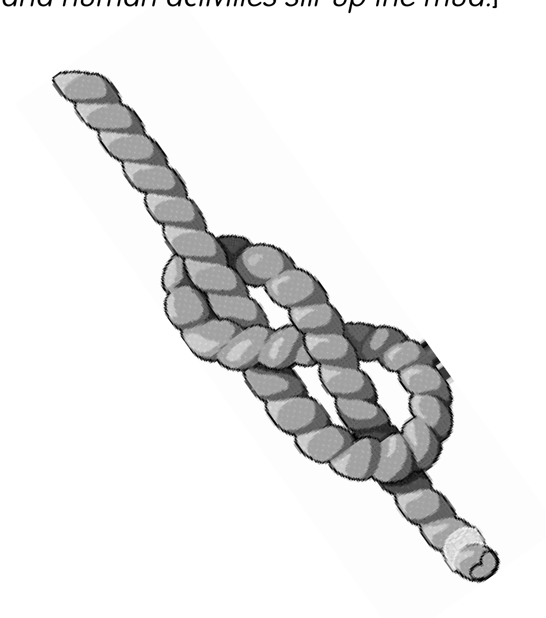
THE ACTION

Period 1

1. Give each pair of students a small sample of mud on a paper plate.
2. Have the students use toothpicks to investigate the composition of the mud sample and classify its components.
3. Discuss the difference between organic materials (decaying plants and animals, bits of leaves and sticks) and inorganic materials (rocks, clay, and sand). Introduce the term "detritus" and discuss what parts of the mud would fit the definition.
4. Ask the students to explain how detritus would be important to an aquatic ecosystem. [*Detritus provides food and shelter for animals, nutrients for plants, and a place where roots can take hold*.]
5. Show the students your sample container and tell them that this sample represents estuary mud of which detritus is a major part. Tell the students that they will conduct an experiment that simulates how mud settles in an estuarine habitat.
6. Divide the class into groups of four and distribute the following materials to each group: one 2-liter clear soda bottle, a ruler, masking tape and a marker.
7. Have the students mark their containers at the 3" and 6" levels and label each container with the names of the participants in each group.

Period 2
Divide the students into their groups and distribute the necessary materials for conducting the experiment. Have the students follow directions on Discovery Sheets #1 and #2.

Period 3
1. Have the students make their final observations for the settling experiment.
2. As a whole class, create a list of different types of water pollution [*e.g. runoff from streets, chemicals from factories, sewage from boats, litter, gasoline, heavy metals, fertilizers, etc*.]. Introduce the terms point source and non-point source pollution. Categorize the list into these two types of pollution.
3. Define PCBs and dioxins. Ask the students to decide where these chemical compounds fit into the pollution categories.
   *NOTE: Initially both compounds were point source pollution, originating from industrial discharge into a waterway. Today, as relatively little or none of these compounds are being discharged, they have become non-point source pollution. They are reintroduced into the environment through various means as bottom sediment is disturbed or as older equipment using these compounds fails or goes out of service.
4. Distribute a small amount of colored beads to each group. Explain that these beads represent chemical pollutants, such as PCBs and dioxins. Instruct each group to add the colored beads to the water in their container. Discuss what happens to the beads.
5. After the beads have settled to the bottom of the container, ask the students to describe what processes or activities would cause the water and sediments to mix [*rain, river water entering the estuary, ocean tides, storms, boat wakes, animal movement, dredging and clearing channels*].
6. Instruct the students to mix the sediments, and then have them explain what happens to the objects that represent the chemical pollutants. [*The beads are redistributed within the sediments*.] Discuss how some contaminants are recycled through the estuary ecosystem. [*Contaminants become available to the plants and animals in the ecosystem when natural events and human activities stir up the mud*.]



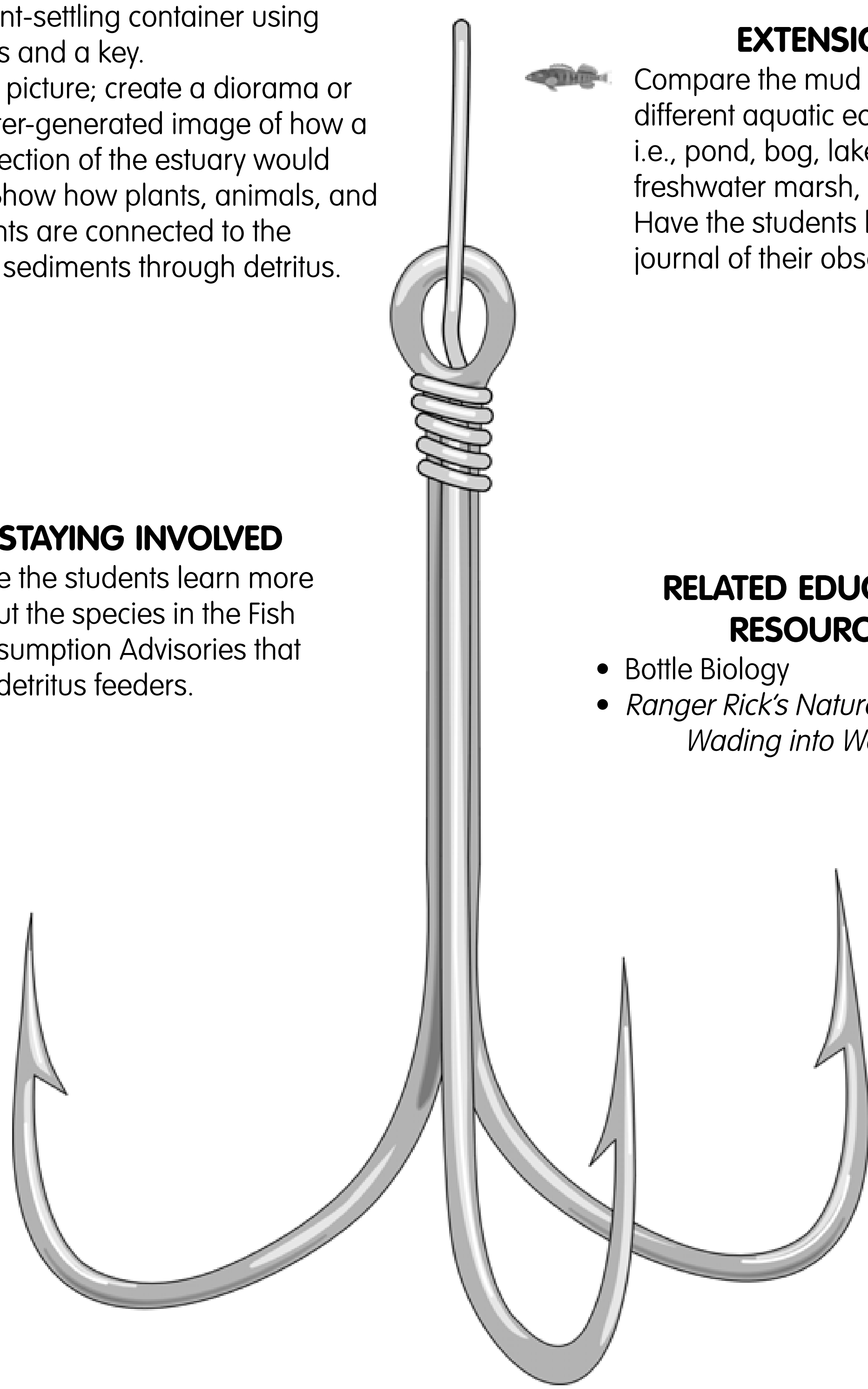
ASSESSMENT STRATEGIES

Have the students:

- ❏ Draw a cross-section of their sediment-settling container using symbols and a key.
- ❏ Draw a picture; create a diorama or computer-generated image of how a cross-section of the estuary would look. Show how plants, animals, and pollutants are connected to the bottom sediments through detritus.

STAYING INVOLVED

Have the students learn more about the species in the Fish Consumption Advisories that are detritus feeders.



EXTENSIONS

Compare the mud from different aquatic ecosystems, i.e., pond, bog, lake, swamp, freshwater marsh, river, etc. Have the students keep a journal of their observations.

RELATED EDUCATION RESOURCES

- Bottle Biology
- *Ranger Rick's Nature Scope - Wading into Wetlands*

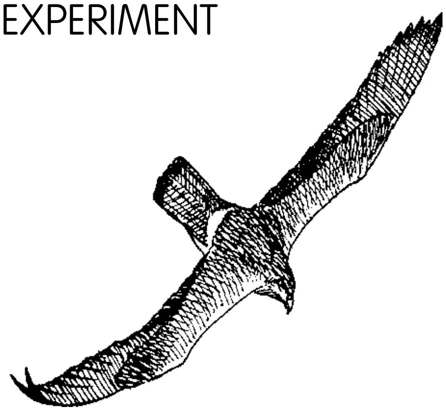
SEDIMENT SETTLING EXPERIMENT - DIRECTIONS

Discovery Sheet #1

Names of Group Participants: ____

Date: ________________________

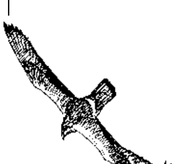
HOW TO CONDUCT THE EXPERIMENT



Assign roles:
Time Keeper ________________________________
Measurer ___________________________________
Recorder____________________________________
Materials Handler ____________________________

PART 1
1. Add mud to the 2" level on your container.
2. Add water until it reaches the 6" level.
3. What happens? Record your observations under Part I on the data sheet.
4. Predict how your mud sample will settle after you mix the mud and water thoroughly.

PART 2
1. Stir the mud and water until everything is mixed well.
   Begin recording the time on the data sheet.
2. At two-minute intervals, measure the thickness of the layer of settled mud.
   Record these measurements next to the time.
3. Continue your observations for 20 minutes.
4. After your last measurement, observe the settled mud and describe what you see in your settling container. Record this under Part 3 on your data sheet.
5. Place the settling container aside. Conduct a final observation in 24 hours.



SEDIMENT SETTLING EXPERIMENT - DATA SHEET

Discovery Sheet #2

Names of Group Participants: ____

Date: ____________________

Part 1: Initial Observations:

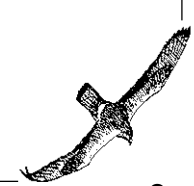
Part 2: The Experiment

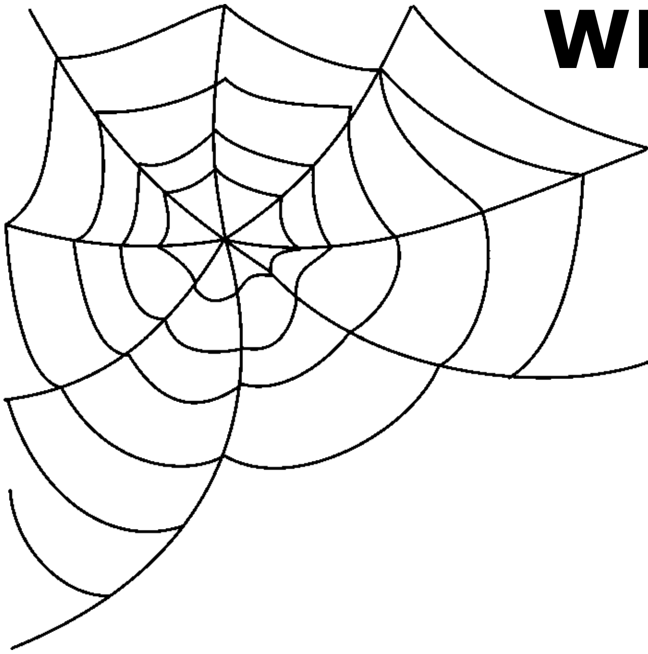
	Time	Layer Thickness
Start	______	________
	______	________
	______	________
	______	________
	______	________
	______	________
	______	________
	______	________
	______	________
	______	________
Finish	______	________
24 hours later		________

Part 3: Observations upon completion:

Part 4: Final observation (after 24 hours)

(Note the color of the sediments, the size and arrangement of particles and the color of the water.)





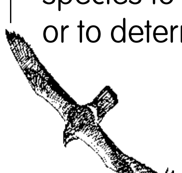
WHO BELONGS?

BACKGROUND INFORMATION

Ecosystem dynamics include the interrelationships between organisms. These consist of, but are not limited to, the interaction of species within a food web. All of the participants (producers, consumers, scavengers and decomposers) are involved in maintaining biological balance. When this balance is tipped for any reason, it produces a ripple effect throughout the system, which can affect various species in different ways.

Indicator species are those plants and animals that help identify a habitat or ecosystem. Skunk cabbage indicates a freshwater wetland habitat whereas blue claw crabs indicate a salt marsh habitat or estuarine ecosystem. When biologists study these natural systems, they look for the presence or absence of these indicator species to help gauge the health of a system or to determine if that system is maintaining its biological balance. As an example, if a marine biologist studying the Newark Bay Complex found a dearth of blue claw crabs, it would raise a red flag and give an indication that the waters in the complex were unsuitable for this previously abundant indicator species. Based on this observation, research could be undertaken to determine why the species' numbers had dropped and if the cause poses any risk to human health. In this way, indicator species often act as environmental barometers.

In depth study of habitats, natural communities, and ecosystems becomes a fairly complicated matter as one looks at the myriad ways that these systems are connected. Whether through a common predator, the flow of groundwater, or a waterborne seed, no natural system exists in a vacuum. Often food chains are the common links between these systems.

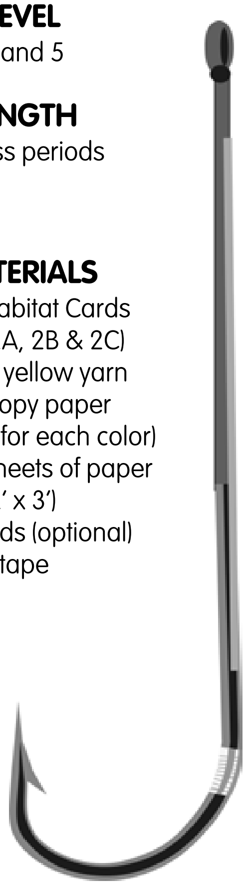


LEVEL
4 and 5

LENGTH
2 class periods

MATERIALS

- o 1 set of Habitat Cards (Figures 2A, 2B & 2C)
- o 3 balls of yellow yarn
- o colored copy paper (2 sheets for each color)
- o 3 large sheets of paper (at least 2' x 3')
- o index cards (optional)
- o masking tape
- o markers
- o string



OVERVIEW

A food web-building activity demonstrates how species from different natural systems interact and how that system's health can be determined by the presence or absence of a specific species.

OBJECTIVES

Students will:

- Describe how energy flows through a food web;
- Explain how organisms from different natural systems interact;
- Demonstrate an understanding of why indicator species help identify specific habitats, natural communities and ecosystems;
- Understand how the presence or absence of an indicator species helps monitor the health of an ecosystem.

ADVISORY LINK

The species listed in the Fish Consumption Advisories are affected by many factors from outside the boundaries of the Newark Bay Complex. To fully understand how these species are impacted by natural and human influences, it is important to understand how these animals interact with species from other aquatic natural systems within the Complex.

KEYWORDS

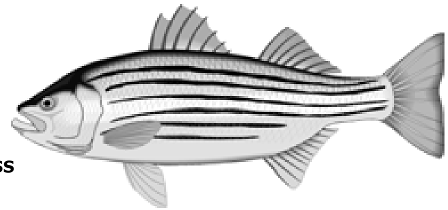
aquatic	estuary	ocean
consumer	food chain	producer
decomposer	food web	river
detritus	habitat	
ecosystem	indicator species	

STUDENTS PREREQUISITES

A basic understanding of river, estuary and ocean ecosystems
An understanding of how food chains and food webs work

PROCESS SKILLS

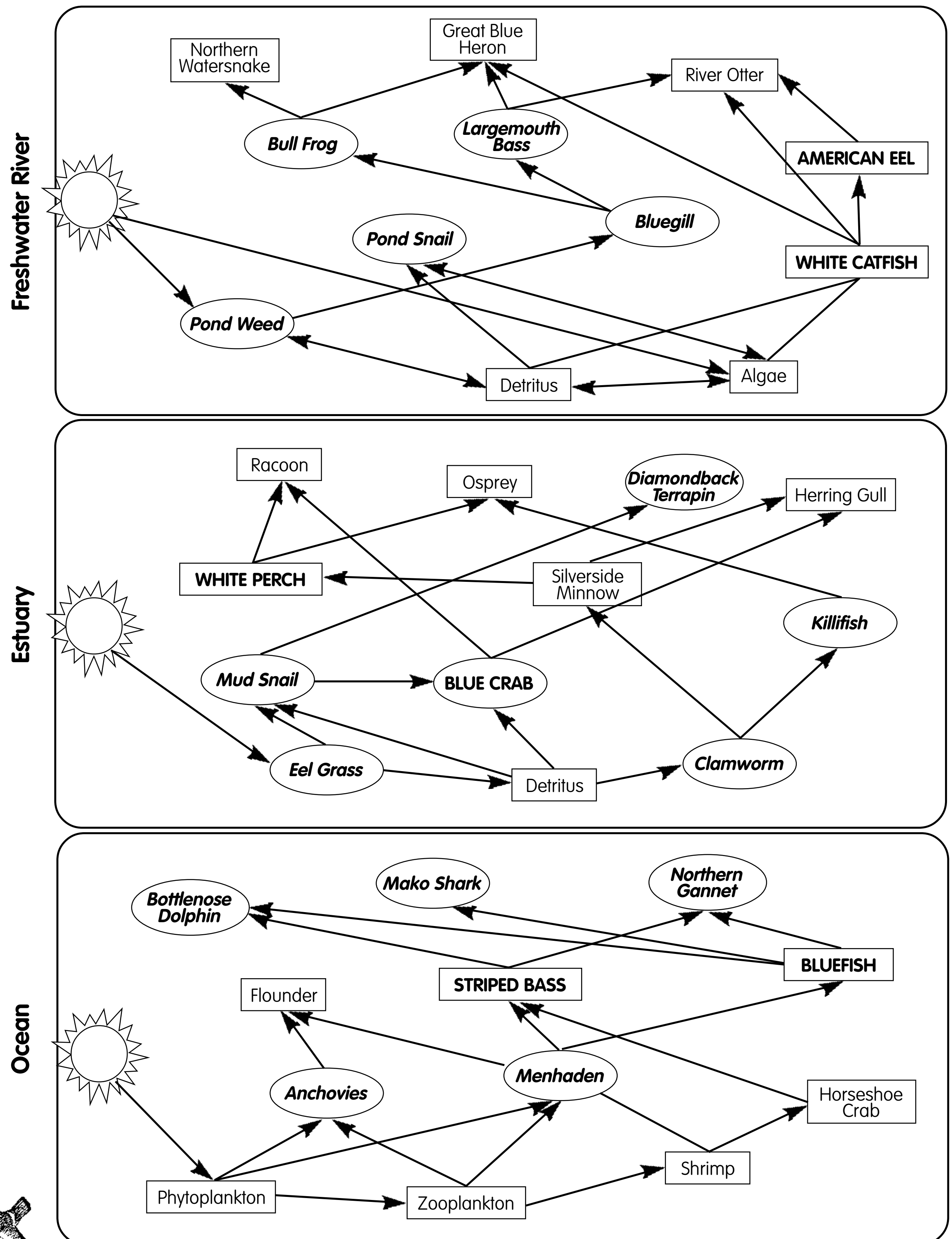
communicating	analyzing
categorizing	synthesizing
inferring	predicting



STRIPED BASS

FIGURE 2D

SAMPLE FOOD WEBS



PLANNING

1. Copy the Habitat and Species Cards (Figures 2A, 2B & 2C) onto three different colored papers. On the cards, all indicator species are in ***bold italics*** and all Fish Consumption Advisory species are in **BOLD** capital letters.
2. Create a "sun" card and a "human" card for each group.
3. Cut the cards apart and mount each on an index card or other stiff paper.
4. Laminate each card or cover in clear contact paper.
5. Copy each sample food web without the arrows (Figure 2D) onto a large sheet of paper. These sheets will be used in the activity after students have created their food chains and food web. Only some of the connections that would occur in each food web are shown.

PROCEDURE
SETTING THE STAGE

Ask several students to describe their favorite food. List the ingredients that are required to make the food. Create a simple food chain to show how energy flows from the sun to the human consumer.

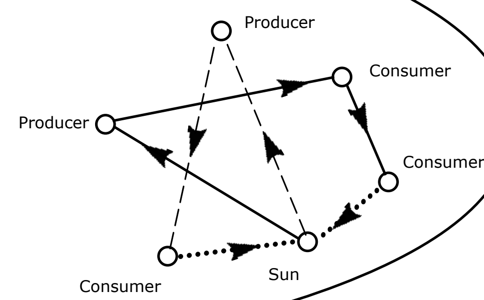
THE ACTION

Period 1

1. Divide the class into three groups that represent the following aquatic systems: freshwater river, estuary, and ocean.
2. Designate one student from each group to be the sun, one to be the human, and another to be the yarn carrier whose job is to transport the yarn ball from person to person during the activity. Distribute a species card (from that natural system) to each additional member of the group.
3. Discuss the terms producer, consumer, and decomposer to review how each organism obtains its food.
4. Distribute a ball of yarn to each group. Tell the students that the yarn represents the sun's energy and should be passed from person to person during the activity.
5. Have each group work together to create a series of food chains using the information given on each card. Once a food chain is complete, return the yarn ball to the sun to start a new chain (Figure 2E). Each student needs to be connected at least once before food web status is achieved.
6. Once each group is finished, have the students place the yarn on the ground and step away from it. Discuss the concept of food web.
7. Post the large species lists on the board or wall. As each habitat group explains their food web to the class, draw these connections on each of the master lists. Ask other students to contribute additional connections.

FIGURE 2E
HOW TO CONNECT THE STUDENTS

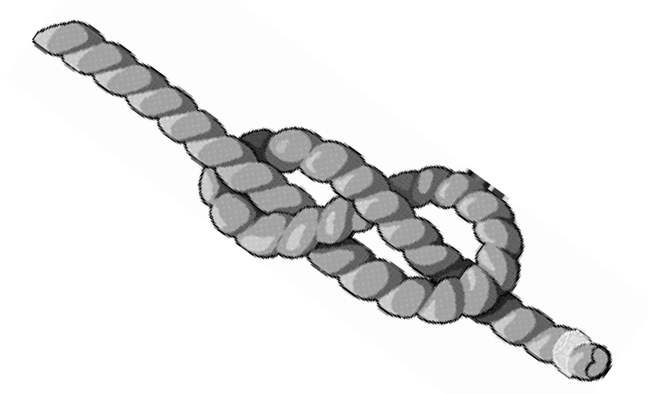
KEY:
1st Food Chain A = ————
Reconnecting to the Sun = ············
2nd Food Chain B = — — — — —



8. Identify the students who represented the indicator species (**bold italics** on the cards). Ask students to speculate why these species belong to a special group. Introduce the term, indicator species, and discuss how these species are significant in determining habitat types and ecosystem health.
9. Identify the students who represented the Fish Consumption Advisory species (**BOLD** capital letters on the cards). Show an example of the Fish Consumption Advisories (Appendix A). Explain why these species have been included on the Advisory list. [*These species are either bottom dwellers or scavengers that have direct contact with contaminated detritus or they eat other animals that have contact with the contaminants*.]

Period 2

1. Tape the food web lists on a wall in order of their flow from freshwater to saltwater (river, estuary, ocean).
2. Divide the class into small groups (their original groups halved) and ask them to write down as many food chains as they can to show how species from <u>different</u> habitats interact. Allow the students to refer to their habitat cards.
3. Have each small group explain one of their food chains. Use string and tape to make these connections between the habitat sheets. Ask the members of each group to describe how the habitats are connected as part of a larger regional natural system.



ASSESSMENT STRATEGIES

Have the students:

- ❑ Describe what might happen to the other members of the food web when the indicator species are removed from each of the habitats.
- ❑ Determine which of the animals and plants within the food web would be more susceptible to change, less susceptible to such changes, and why.
- ❑ Write essays to complete the following newspaper headings. Include information about health effects on the animals and plants within the three habitats and what efforts are being used to remedy the situation:
    1. An oil tanker leaked crude oil into the ocean near Sandy Hook, NJ...
    2. A barge ran aground in the Hudson River and part of its waste load for the landfill was dumped...
    3. Construction along a lakeshore produced sediments that clog the channel going into a nearby river...

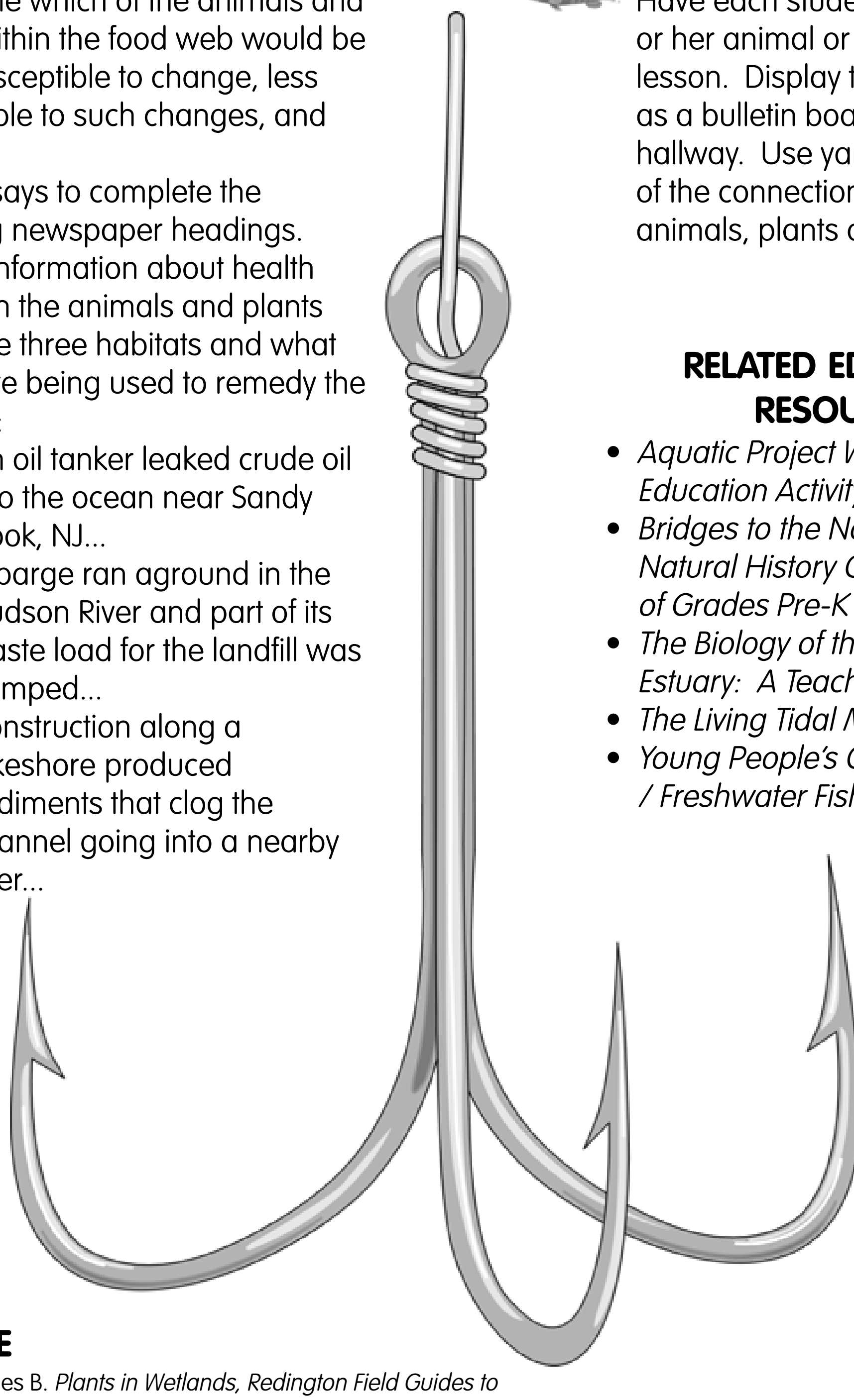
EXTENSIONS

Have the students research their habitat and report on other plants and animals that belong there.

Have each student illustrate his or her animal or plant from the lesson. Display these illustrations as a bulletin board in the hallway. Use yarn to show some of the connections between the animals, plants and habitats.

RELATED EDUCATION RESOURCES

- *Aquatic Project WILD - Aquatic Education Activity Guide*
- *Bridges to the Natural World: A Natural History Guide for Teachers of Grades Pre-K to Six*
- *The Biology of the Hudson-Raritan Estuary: A Teacher's Guide*
- *The Living Tidal Marsh*
- *Young People's Guide to Saltwater / Freshwater Fishing*



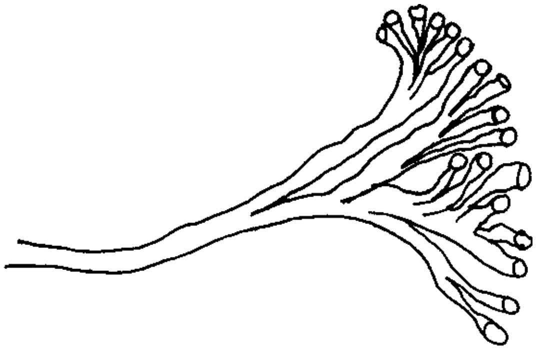
REFERENCE

Redington, Charles B. *Plants in Wetlands, Redington Field Guides to Biological Interactions.* Kendall/Hunt Publishing Co., Dubuque, Iowa. 1994.

Reid, George K., Ph.D. *Pond Life: A Guide to Common Plants and Animals of North American Ponds and Lakes.* Golden Press. NY. 1987.

FRESHWATER RIVER

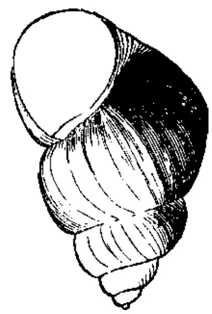
FIGURE 2A



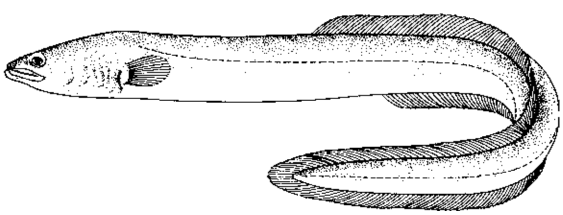
Algae: producer

Detritus: bits of dead plant & animal matter

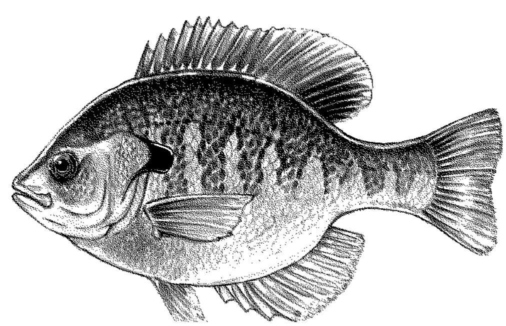
Pondweed: producer



Pond Snail: consumer, scavenger
Eats: algae, aquatic plants, detritus



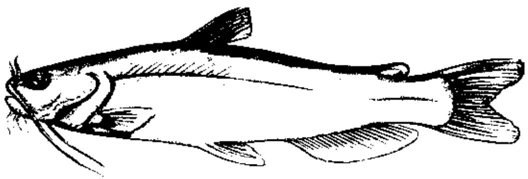
AMERICAN EEL: consumer
Eats: fish, plants, crustaceans, worms



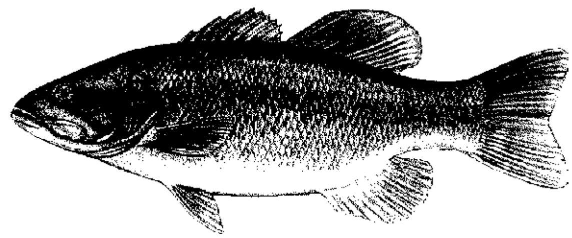
Bluegill: consumer
Eats: insects, crustaceans,
small aquatic animals

FRESHWATER RIVER

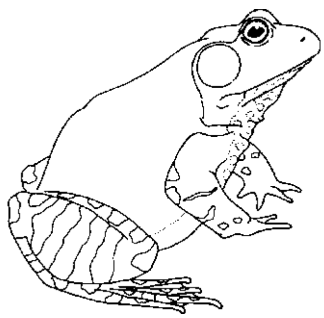
FIGURE 2A (continued)



WHITE CATFISH: consumer
Eats: detritus, plants

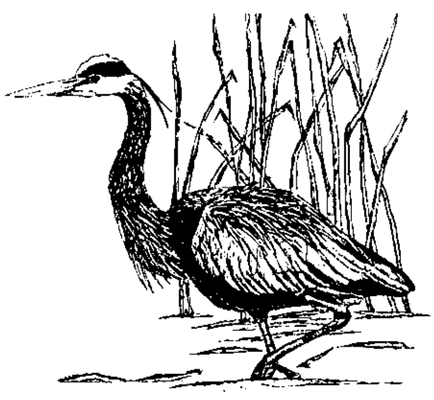


Largemouth Bass: consumer
Eats: smaller fish

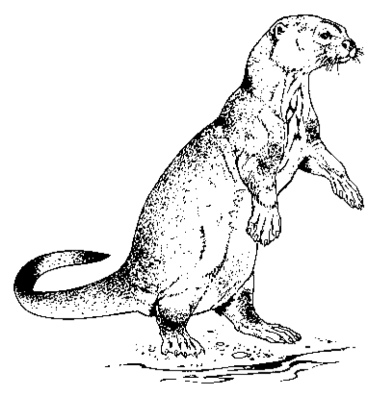


Bullfrog: consumer
Eats: insects, frogs, small fish

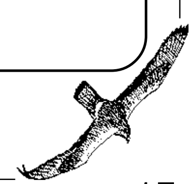
Northern Watersnake: consumer
Eats: frogs, fish, salamanders, crustaceans, small mammals



Great Blue Heron: consumer
Eats: fish, small mammals, frogs, snakes



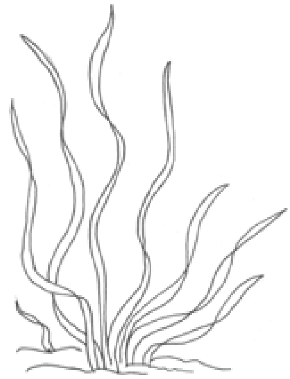
River Otter: consumer
Eats: fish, snakes, frogs



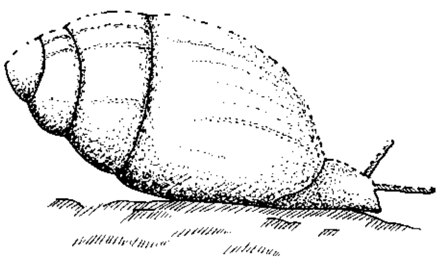
ESTUARY

FIGURE 2B

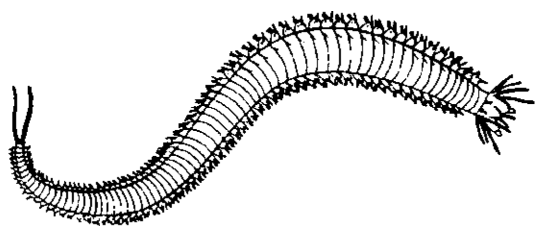
Detritus: bits of dead plants & animals



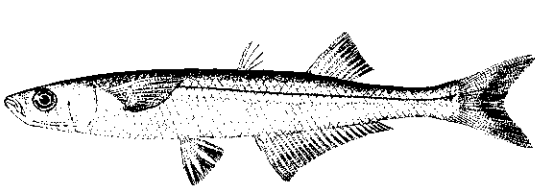
Eel Grass: producer



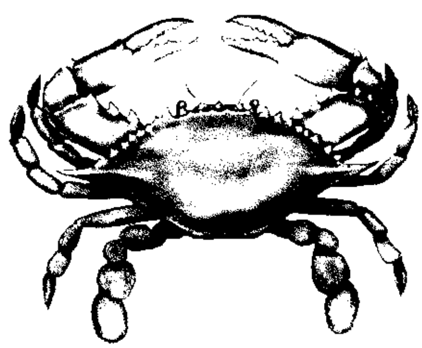
Mud Snail: consumer, scavenger
Eats: plants, detritus



Clamworm: consumer, scavenger
Eats: detritus, other clamworms



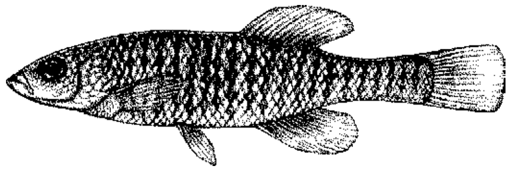
Atlantic Silverside: consumer
Eats: algae, shrimp, crustaceans, insects, worms, horseshoe crab larvae



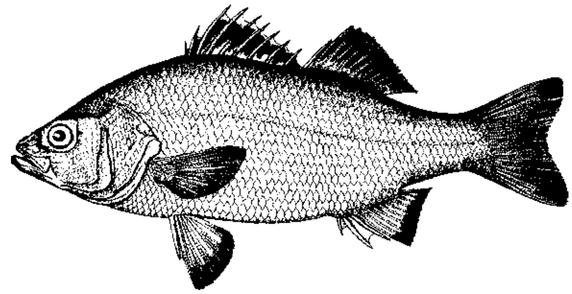
BLUE CLAW CRAB: consumer, scavenger
Eats: worms, plants, crustaceans, detritus, fish

ESTUARY

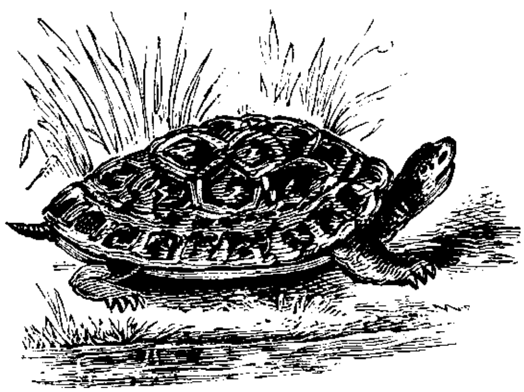
FIGURE 2B (continued)



Killifish: consumer, scavenger
Eats: vegetation, worms, detritus, crustaceans, mosquito larvae

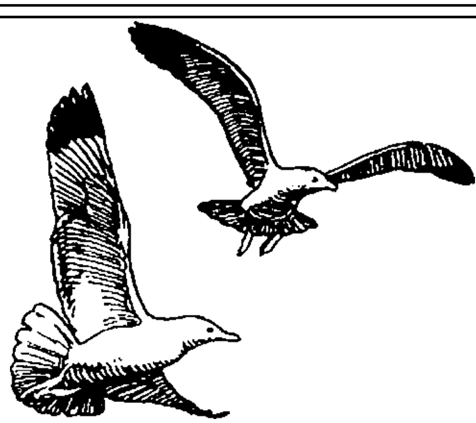


WHITE PERCH: consumer
Eats: some plant species, worms, detritus, crustaceans, fish, crabs



Diamondback Terrapin: consumer
Eats: marine snails, clams, worms

Osprey: consumer
Eats: all types of larger fish

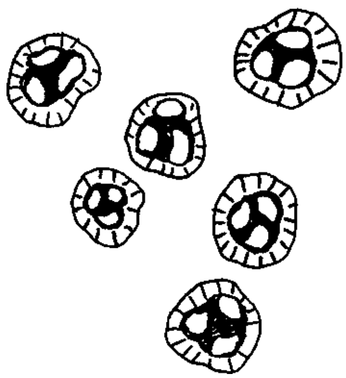


Herring Gull: consumer, scavenger
Eats: small fish, most any type of animal

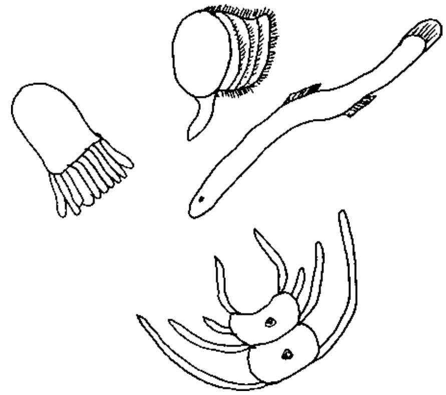
Raccoon: consumer
Eats: frogs, large insects, bird eggs, small mammals, crabs, fish

OCEAN

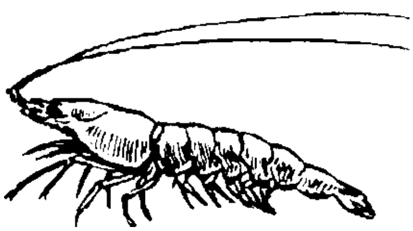
FIGURE 2C



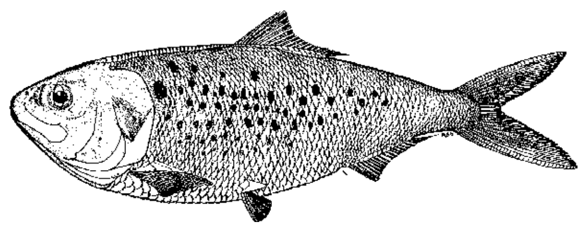
Phytoplankton: producer



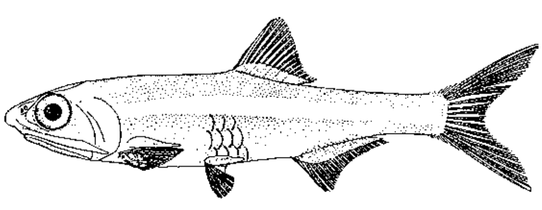
Zooplankton: consumer
Eats: phytoplankton & other zooplankton



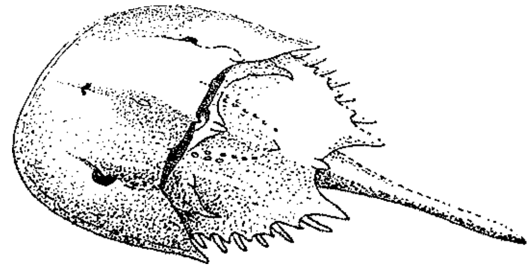
Shrimp: consumer
Eats: phytoplankton



Menhaden: consumer
Eats: phytoplankton, small crustaceans



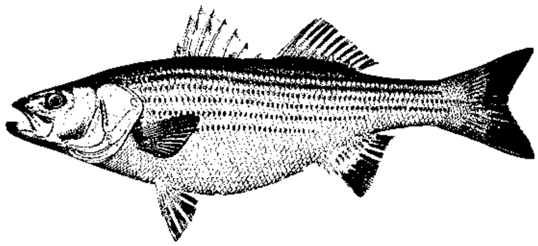
Anchovy: consumer
Eats: zooplankton, marine worms, small crustaceans



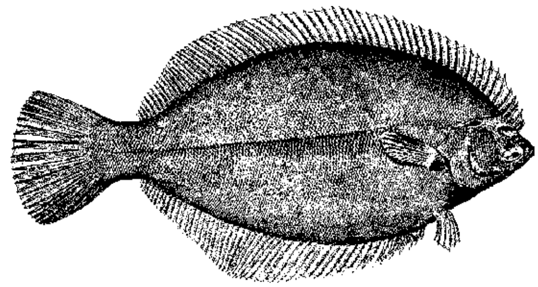
Horseshoe Crab: consumer, scavenger
Eats: worms, small crabs, shrimp, dead fish

OCEAN

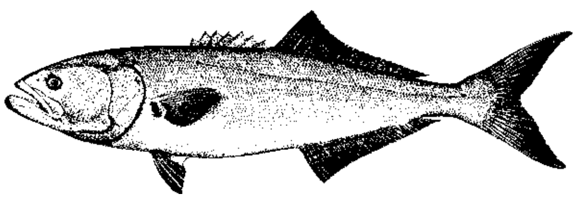
FIGURE 2C (continued)



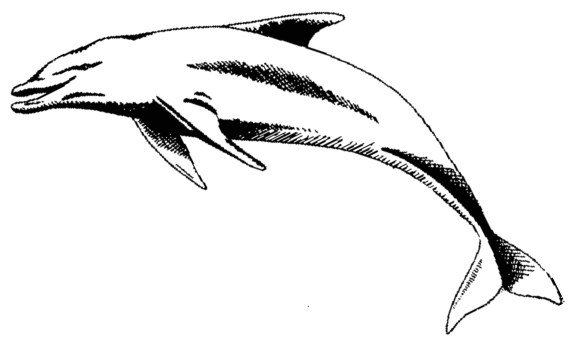
STRIPED BASS: consumer
Eats: menhaden, silversides, blue crabs, horseshoe crab larvae, shrimp, clams



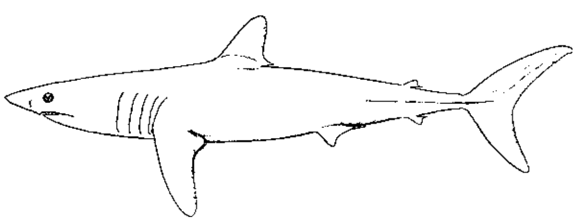
Flounder: consumer
Eats: worms, small fish, shrimp, Atlantic silversides, killifish



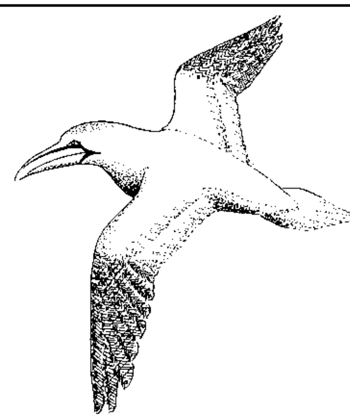
BLUEFISH: consumer
Eats: menhaden, silversides



Bottlenose Dolphin: consumer
Eats: all types of fish



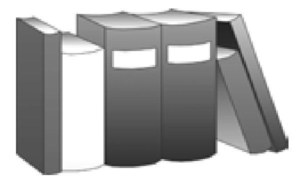
Mako Shark: consumer
Eats: all types of fish



Northern Gannet: consumer
Eats: all types of fish

YOU ARE WHAT YOU EAT

BACKGROUND INFORMATION



Many potentially harmful substances have been introduced into the environment. Some of these are biodegradable and, over time, have little long-term effect on the health of the ecosystem. Others, such as synthetic organic chemicals (PCBs, dioxins, chlordane) do not biodegrade to the same degree, but remain in the environment. Since these chemicals are toxic at certain concentrations and some are possible carcinogens, they are considered potentially harmful to the animals living in or depending on the affected ecosystem.

These substances are not soluble in water and tend to concentrate in bottom sediments. The chemicals may be ingested by aquatic animals that rely on the nutrients they receive from the detritus in the sediments. Once these chemicals enter the animal they are difficult to excrete and over time become stored in the animal's fatty tissue. This process, called bioaccumulation, may not kill the animal, but, when it becomes prey to another animal, all of the original animal's "chemicals" are taken into the new animal's body. The chemical builds up in the new animal's body as it eats more and more of the affected species. During this process of biomagnification, the new animal may store enough of these contaminants in its body to elicit adverse health effects (See Figure 3C). The long term effects of small amounts of these contaminants and their possible impact on humans are not well understood, although the Fish Consumption Advisories give guidelines for minimizing risk to humans who eat the affected animals.

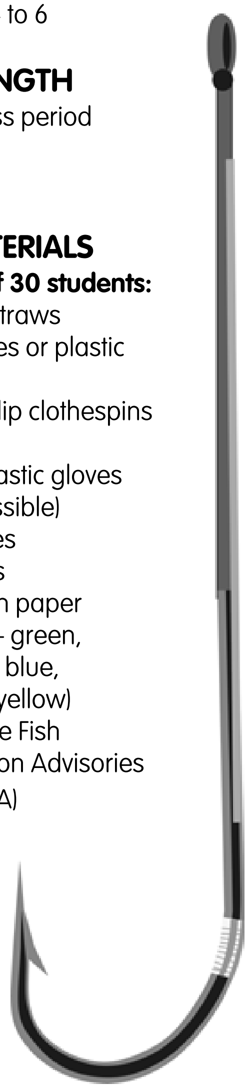
LEVEL
4 to 6

LENGTH
1 class period

MATERIALS

For a class of 30 students:

- o 20 plastic straws
- o 15 envelopes or plastic baggies
- o 10 spring-clip clothespins or tongs
- o 3 sets of plastic gloves (blue, if possible)
- o paper plates
- o paper bags
- o construction paper (18 pieces – green, 18 pieces – blue, 4 pieces – yellow)
- o 1 copy of the Fish Consumption Advisories (Appendix A)



OVERVIEW

An active game demonstrates how toxins can accumulate in the bodies of animals in an estuary food chain.

OBJECTIVES

Students will:

- Describe how energy moves through an estuarine food chain;
- Explain the processes of bioaccumulation and biomagnification;
- Describe how bioaccumulation and biomagnification can affect people.

ADVISORY LINK

The New Jersey Department of Environmental Protection, Division of Science and Research found unsafe levels of dioxins and PCBs in some species of fish and crabs in the Newark Bay Complex. These chemicals are classified by the federal Environmental Protection Agency as probable cancer causing substances in humans. As these toxins move through the estuarine food chain, they become more concentrated in higher order consumers. The Fish Consumption Advisories give guidelines for anglers to follow when they consider consuming specific fish and crabs from these waters.

KEYWORDS

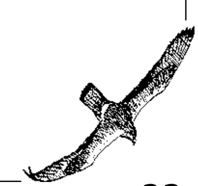
bioaccumulation	contaminant	estuarine
biomagnification	detritus	PCBs
consumer	dioxins	producer

STUDENT PREREQUISITES

An understanding of how food chains and food webs function
The basics of an estuary habitat

PROCESS SKILLS

communicating	interpreting data
measuring	formulating hypotheses
counting	



PLANNING

1. Cut paper for food markers. For each student who represents an oyster, cut nine green markers for decaying vegetation, nine blue markers for decomposing animal matter and two yellow markers for toxins.
2. Assemble the other materials and find a site for the game.
3. Make one copy of Figure 3C for each student.

PROCEDURE
SETTING THE STAGE

Display pictures of the three animals that are represented in the game (Figure 3B). Ask the students if they have seen any of these animals, and if so, in what context. Explain to the students that each of them is going to assume the role of one of these animals in a food chain game.

THE ACTION

Pre-Game

1. Write the following ratio on the blackboard 6:3:1. This explains an approximate number of oysters to crabs to gulls in the environment. Have the students determine how many of each animal should be represented based on the total number of students in the class (in a class of 30 students there should be 18 oysters, 9 blue crabs, and 3 herring gulls).
2. Discuss the significance of the ratio. [*There are more first order consumers (oysters) than second order consumers (blue crabs), and more second order consumers than top consumers (herring gulls)*].

Game

1. Assign roles to the students. Players are hereafter referred to as oysters, crabs, and gulls.
2. Instruct the students representing oysters to sit on the ground. (Oysters grow by attaching themselves to a stationary object.) Discuss how oysters feed by filtering microscopic zooplankton and phytoplankton from the surrounding water. Give each oyster a plastic straw that they will use to pick up their food markers.
3. Spread the food markers all around the oysters. Note: Do not explain the color representations.
4. On your signal have the oysters collect as many food markers as possible using their straws and without moving

FIGURE 3A

GAME RESULTS

	GREEN MARKERS	BLUE MARKERS	YELLOW MARKERS
OYSTERS			
1.			
2.			
3.			
4.			
5.			
etc.			
BLUE CRABS			
1.			
2.			
3.			
4.			
5.			
etc.			
HERRING GULLS			
1.			
2.			
3.			
4.			
5.			
etc.			

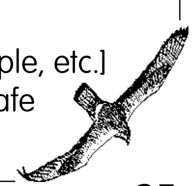
from their spots. Collected food markers should be placed on a paper plate. (Hint: In case the students do not discover how to pick up the markers, show them that they can position an open end of the straw on top of the marker, suck on the other end, and thus pull the paper off the floor.)

5. After most of the food has been collected, tell the oysters to stop. Leave the remaining food markers where they are.
6. Instruct the oysters to separate the food markers they collected according to colors, and then count the number for each color. Record the results on a chart similar to Figure 3A.
7. Have the oysters remain seated with their food plates in front of them.
8. Send the blue crabs onto the field. Using clothespins or tongs (crab claws), these students collect the markers (picking them up one by one and placing them in a baggie) from each oyster they visit. As soon as all the food from an oyster has been taken, the oyster leaves the playing field and the crab may move to another oyster.
9. After most of the oysters have been consumed, pause the game and instruct the blue crabs to count their food markers the same way as the oysters did. Record the results.
10. The blue crabs go back onto the playing field. Discuss where crabs live in the estuary [*along the water's edge, on mudflats, in vegetation, under the water*]
11. Tell the crabs that they may move around the playing field to stay away from the gulls. Gulls try to tag a crab with their gloved hands. When this happens, they put the crab's food into their paper bag and the crab is out of the game. Gulls may move freely around the field until the teacher yells WAVE. At this time every gull must freeze but crabs may continue to move. Discuss the real life parallel. [*When water flows over the crabs, it is difficult for a gull to find and eat it.*] When the teacher yells EAT, the gulls may chase the crabs again.
12. Continue until there are two crabs left, and then instruct the gulls to count their markers and record the results.

CLOSING DISCUSSION

Explain that in the game, the blue and green markers represented detritus and the yellow markers represented toxins that are present in the detritus. Discuss PCBs and dioxins as two of the contaminants affecting animals in the Newark Bay Complex.

1. What do you think happens to the nutrients that the animals get from the detritus? [*The nutrients are used for life functions, they are passed through the animals' systems, and they are transferred to another animal when it gets eaten.*]
2. What do you think happens to the toxins? [*These types of chemicals are stored in the fatty tissue of the animals; they do not pass through the animals' systems, and the toxins are passed from one animal to the next in the food chain.*]
3. Based on the game, in which animals did most of the toxins accumulate? [*the gulls*]
4. How did the gulls accumulate the toxins? [*The gulls ate other animals that were contaminated.*] To discuss how the chemicals might affect species that have them in their bodies, have the students review the results. If a gull had between 5 and 10 yellow markers it was fine, between 11 and 20, it was sick, and if it had more than 20 markers, that gull did not survive. Use Figure 3C to discuss biomagnification.
5. List other consumers of oysters and blue crabs. [fish, other birds, raccoons, people, etc.]
6. Introduce the Fish Consumption Advisories as a source for learning about the safe consumption of possibly affected species (Appendix A).



ASSESSMENT STRATEGIES

Have the students:

- ❏ Create a visual representation of the action that occurred during the game. Suggestions: Diagrams, flow charts, sketches, diorama, comic strips.
- ❏ Graph the results of the game to explain the process of bioaccumulation.

EXTENSIONS

- Have students research other food chains that would be affected by bioaccumulation and substitute these animals for the original ones.

- Challenge the students to create a board game that reflects the simulation.

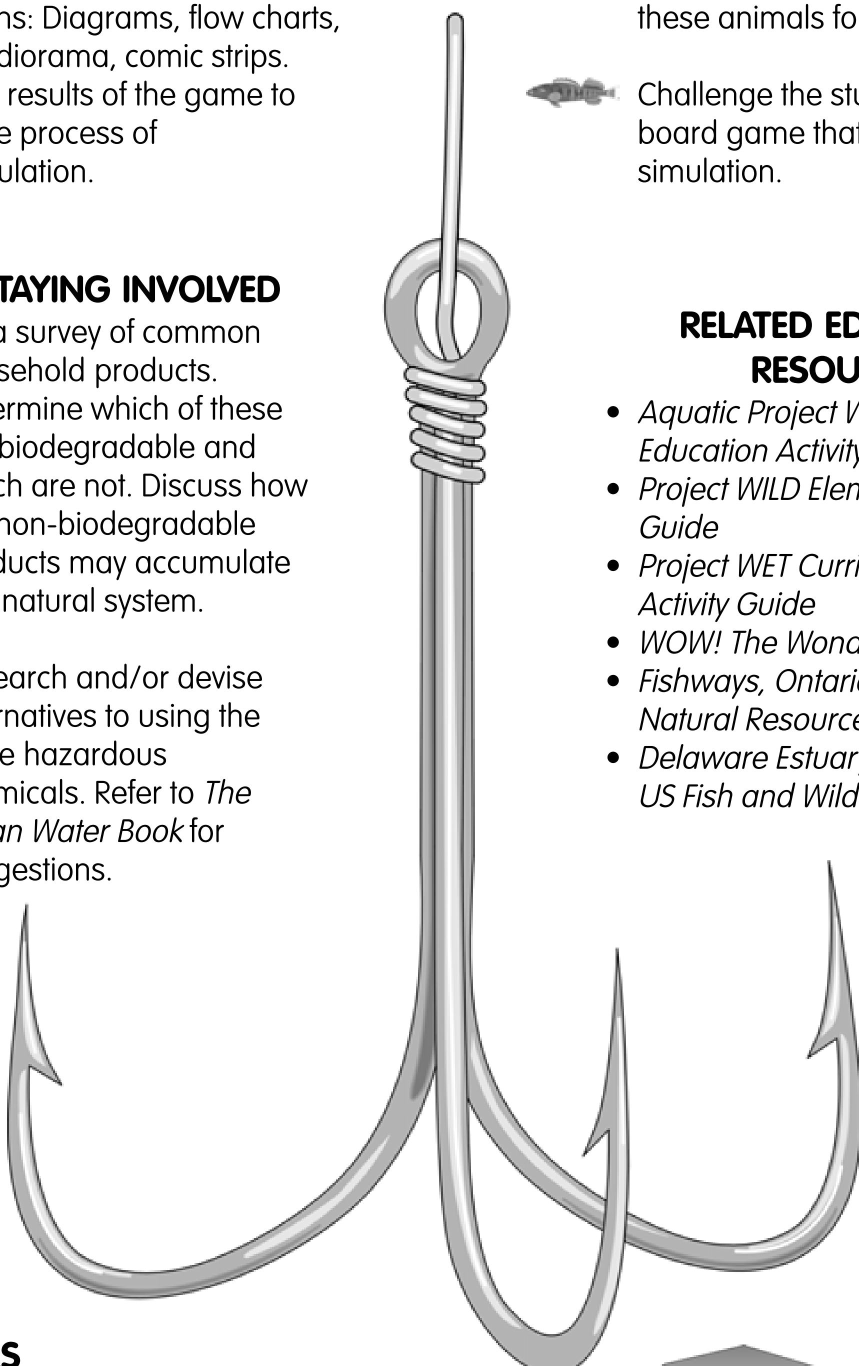
STAYING INVOLVED

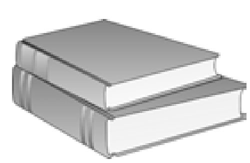
- Do a survey of common household products. Determine which of these are biodegradable and which are not. Discuss how the non-biodegradable products may accumulate in a natural system.

- Research and/or devise alternatives to using the more hazardous chemicals. Refer to *The Clean Water Book* for suggestions.

RELATED EDUCATION RESOURCES

- *Aquatic Project WILD: Aquatic Education Activity Guide*
- *Project WILD Elementary Activity Guide*
- *Project WET Curriculum and Activity Guide*
- *WOW! The Wonders of Wetlands*
- *Fishways, Ontario Ministry of Natural Resources 1991*
- *Delaware Estuary Issues, US EPA, US Fish and Wildlife Service*

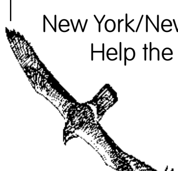




REFERENCES

Hoffman, Kyra. *The Clean Water Book: Lifestyle Choices for Water Resource Protection.* New Jersey Department of Environmental Planning.

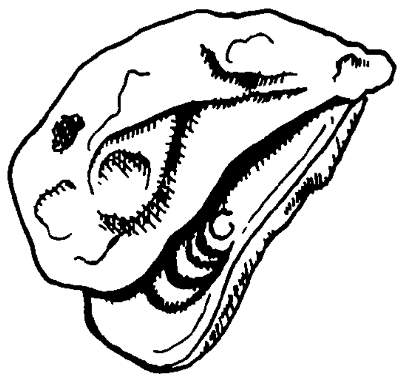
New York/New Jersey Harbor Estuary Program. Pamphlets entitled "You Can Help the Harbor"



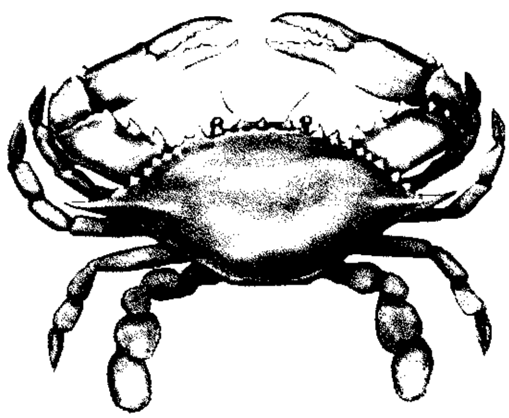
ESTUARY ANIMALS

Figure 3B

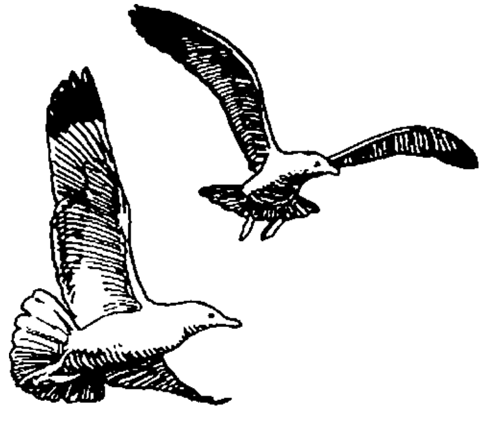
OYSTER



BLUE CLAW CRAB



HERRING GULL



BIOMAGNIFICATION IN THE FOOD CHAIN

Figure 3C

LEVEL

6 When many bluefish or striped bass are eaten by a predator such as an osprey or possibly a person, very high concentrations of the chemical can remain in their fatty tissues.

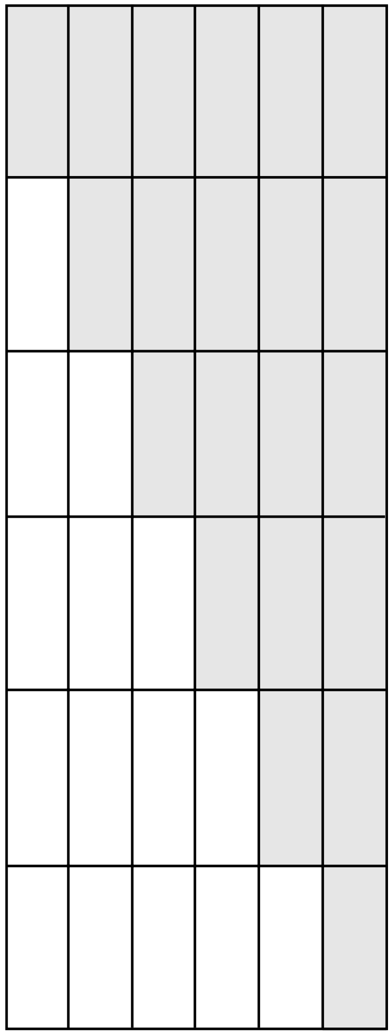
5 When a bluefish or striped bass, at the top of this food chain, eats many of the affected white perch, the result is very high amounts of chemical concentrated in the bluefish.

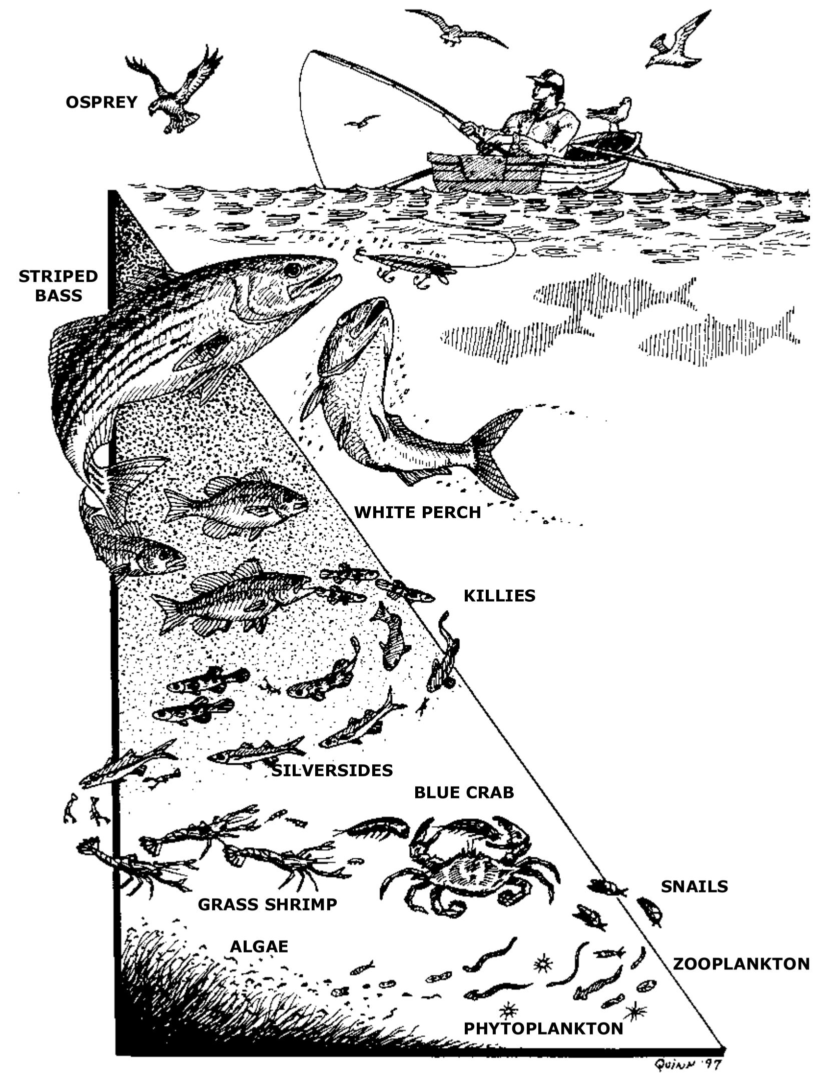
4 Further biomagnification occurs when a white perch eats many of the affected minnows.

3 A silverside minnow stores all the chemicals acquired from eating the zooplankton. This increases the amount of chemical available to the next level of consumer.

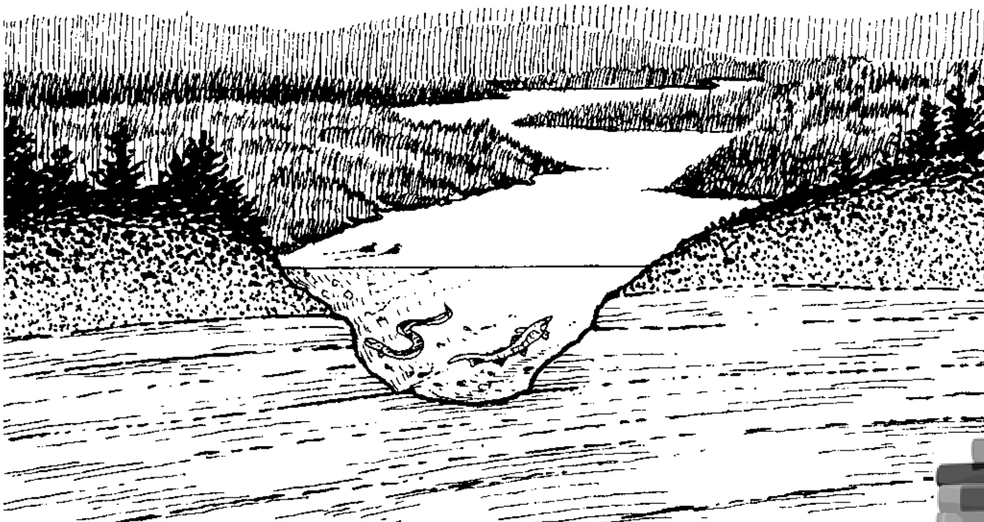
2 Small animals (zooplankton) eat some of the affected plants and animals.

1 Single-celled plants like algae (at the bottom of the aquatic food chain) store small amounts of a chemical that it gets from the estuary mud. This chemical does not leave the plant.





THE WORKS

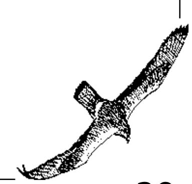


BACKGROUND INFORMATION

A watershed is defined as the land area that drains into a specific body of water such as a river, stream, lake or estuary. Watersheds come in a variety of sizes – they can be as small as the land area that surrounds a catchment basin in a housing development or as large as the land area that surrounds an entire river system. Regardless of size, any natural or human-made environment that exists within its boundaries becomes an integral part of the watershed's regional system.

To identify the boundaries of a watershed, it is necessary to read the earth's topography. Topographic maps, which show elevation as contour lines, help the map-reader visualize the watershed's boundaries. High elevations separate one watershed from another and the positions of low elevations help determine how water will drain off the land and where it will collect. Although water collection sites can be categorized into several types of aquatic habitats (pond, lake, stream, river, estuary, bog), each site will have some of its own unique properties, depending on geology and soil type.

By looking at the topographic maps for an individual watershed, it is easy to see the continuity of river systems and how these systems are connected to lakes, ponds, marshes, estuaries, and reservoirs. Further interpretation will show how the contours of the terrestrial habitats adjacent to these waterways determine the direction of water flow. A complete study of the watershed system will help teach about human land use and how these actions contribute to water quality and quality of life issues.



LEVEL
6 to 8

LENGTH
3 class periods

MATERIALS

For each small group or pair of students:
- o one clear plastic box with clear lid (at least shoebox size)
- o several rocks or clay
- o spray mister
- o non-permanent marker
- o ruler
- o container of colored water
- o topographic map that includes the school

For the class:
- o 1 set of habitat sketches (Figures 4B & 4C)
- o food coloring
- o paper towels
- o newspapers
- o aluminum foil
- o tracing paper

Overview

Hands-on model building introduces students to topographic maps, their local watershed and how habitats within a regional ecosystem are connected.

Objectives

Students will:

- Understand the basic structure of a watershed;
- Identify aquatic habitats within a regional watershed;
- Interpret three-dimensional models and topographic maps;
- Understand how habitats within a region create an integrated ecological system.

ADVISORY LINK

The species listed in the Fish Consumption Advisories spend all or part of their life cycle in the estuary ecosystem. The estuary is part of a larger regional system called a watershed, which encompasses diverse natural and human-made environments.

KEYWORDS

bedrock	freshwater marsh	tidal marsh
contour lines	habitat	topographic map
ecosystem	landform	topography
elevation	salt marsh	upland
estuary	slope	watershed

STUDENT PREREQUISITES

Practice in map reading
An understanding of "habitat"

PROCESS SKILLS

communicating	predicting
observing	synthesizing
analyzing	comparing
measuring	formulating hypotheses

PLANNING

1. Obtain a topographic map of the area around your school.
   These can be purchased at sports/camping stores, from the *New Jersey Atlas & Gazetteer* by DeLorme or by ordering through the NJ Department of Environmental Protection (DEP) Publications Catalog: Map and Publications Sales, NJDEP, PO Box 417, Trenton, NJ 08625-0417 (609) 777-1038.
   They can also be downloaded from the NJDEP website at http://www.state.nj.us/dep/njgs/geodata/index.htm
2. Make copies of Figure 5C – Watersheds of Northern New Jersey.
3. Assemble the materials for the model demonstrations and the clean-up equipment.
4. Copy Figures 4B and 4C to display to the class.

PROCEDURE
SETTING THE STAGE

Ask the students to identify various locations in town that show examples of low and high elevation. Create a list of resources where the students could find more information about the elevation of these specific sites.

THE ACTION

Period 1

1. Divide the class into groups of not more than four students per group.
2. Read aloud the directions for creating a watershed model. Have the students take "step by step" notes to create their model using the materials supplied.

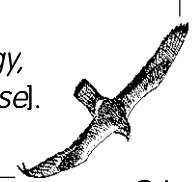
FIGURE 4A
HOW TO CREATE A WATERSHED MODEL

Step 1 Distribute a clear plastic container with a clear plastic lid and rocks or clay to each small group of students

Step 2 Have the students arrange the rocks or clay to form higher elevations and lowland areas.

Step 3 Cover the rocks and clay with plastic or foil to create indentations for lakes, marshes and other water habitats.

3. Create a class list of the various landforms represented on the models. Relate these to similar sites from around town.
4. Discuss the factors that would determine the direction water would flow [*geology, limnology, soils, topography, gravity, the path of least resistance, human land use*]. Ask the students to predict where water would collect on their models.



5. Ask the students to name the types of habitats that might be associated with these collection sites. Use Figures 4B and 4C to help the students visualize how these aquatic habitats might look. Discuss which of these water habitats would channel water [*river/stream*] and which would store water [*pond/lake, marshes*].
6. Provide each group with a spray mister filled with water. Instruct the students to place their models on newspaper, and then spray water on the model to simulate a rainstorm. Discuss the results.
7. Have the students count how many "collection areas" they have on their models.
8. Define "watershed." Discuss how a watershed's size varies depending on the amount of land that is drained.
9. Have students explain how smaller watersheds may be a part of a larger watershed.
10. Ask the students to explain how water and land habitats are connected. [W*ater from rain and snow melt runs off the land into waterways. Smaller waterways are connected to larger waterways and eventually will connect to the estuary and the ocean. Streams and river travel through marshes, ponds, swamps, lakes and reservoirs*.]
11. Distribute copies of Figure 5C for the students to see. Identify the subwatershed and watershed in which their school exists.

Period 2

Have the students translate their 3-D model into a flat map by following these steps:

1. Use a ruler to mark the outside vertical wall of the container at ½" intervals.
2. Pour colored water into the container until it reaches the first ½" mark.
3. Place the clear top on the container and trace the water level line on the plastic top with a non-permanent marker.
4. Repeat Steps #2 and #3 until the container has been filled to the top mark on the outside wall.
5. Remove the container's top. As the students look at the top, explain that each line drawn is called a contour line. These continuous lines represent points on the surface of the earth that have the same elevation.

Period 3

Distribute one sample topographic map that includes your school to each small group. Refer back to the maps that the students created using the 3-D model. Ask the students to study the sample map and to write five questions about how to read the map. Use the students' questions to stimulate a discussion; include the following:

- What does a topographic map represent? [*the physical features of a region*]
- How are the gradations on different slopes represented? [*Steep slopes are indicated by closely drawn contour lines; gentle slopes have contour lines that are drawn farther apart.*]
- How is elevation shown? [*Thick contour lines have numbers that represent elevation in feet.*]
- How can you tell if there is a stream, river, or other body of water shown on the map? [*All water is drawn in blue and marshes have a blue symbol that looks like blades of grass.*]

ASSESSMENT STRATEGIES

Have the students:

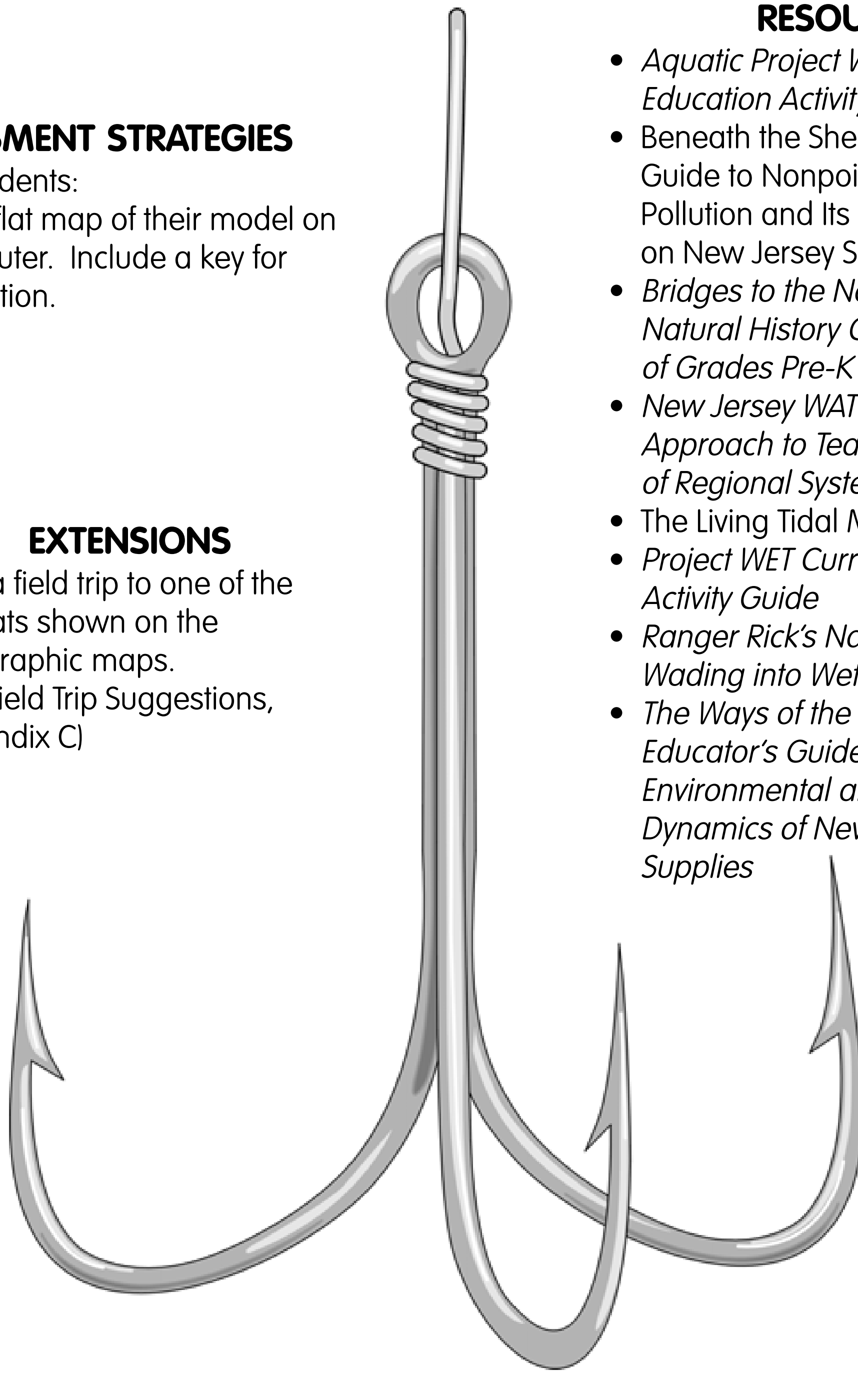
❑ Create a flat map of their model on the computer. Include a key for interpretation.

EXTENSIONS

Plan a field trip to one of the habitats shown on the topographic maps. (See Field Trip Suggestions, Appendix C)

RELATED EDUCATION RESOURCES

- *Aquatic Project WILD: Aquatic Education Activity Guide*
- Beneath the Shell: A Teacher's Guide to Nonpoint Source Pollution and Its Potential Impact on New Jersey Shellfish
- *Bridges to the Natural World: A Natural History Guide for Teachers of Grades Pre-K through Six.*
- *New Jersey WATERS: A Watershed Approach to Teaching the Ecology of Regional Systems*
- The Living Tidal Marsh
- *Project WET Curriculum and Activity Guide*
- *Ranger Rick's NatureScope: Wading into Wetlands*
- *The Ways of the Watersheds: An Educator's Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*

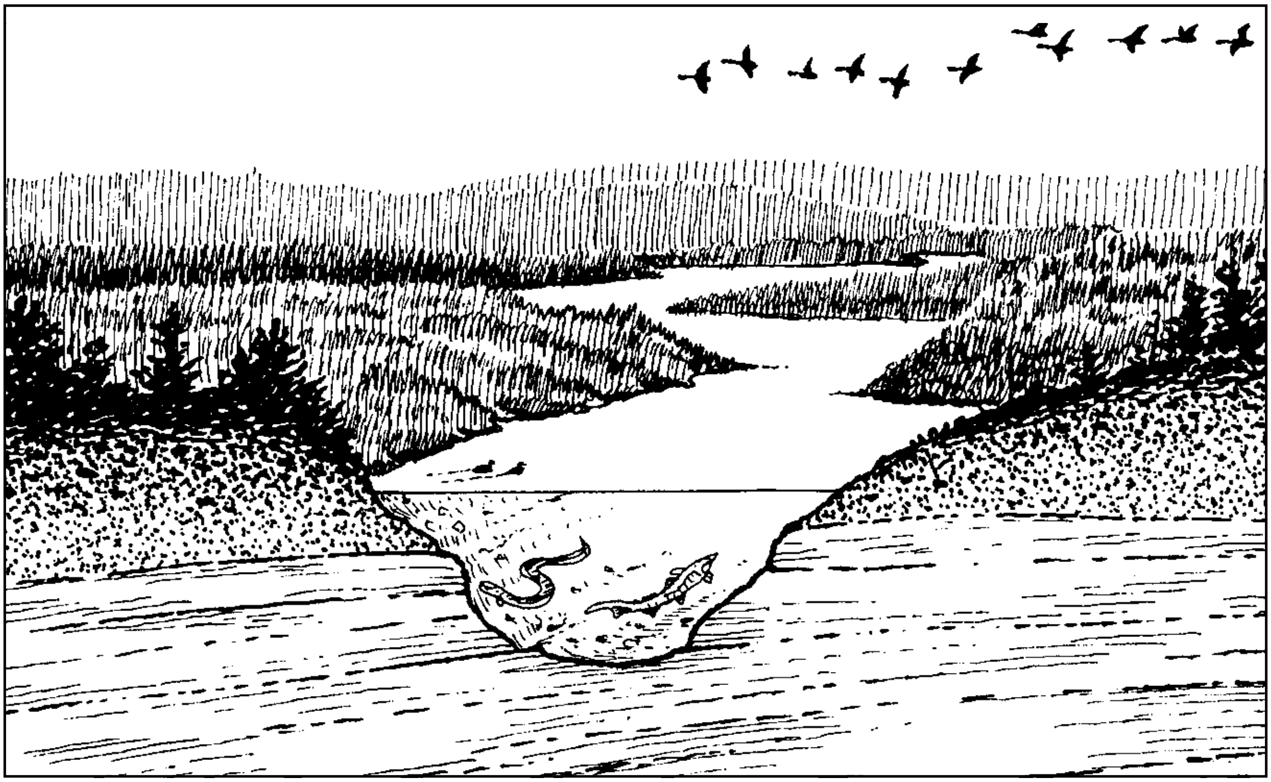


REFERENCE

New Jersey Atlas & Gazetteer. DeLorme. Yarmouth, ME. 1999.

FIGURE 4B

STREAM or RIVER HABITAT



POND or LAKE HABITAT

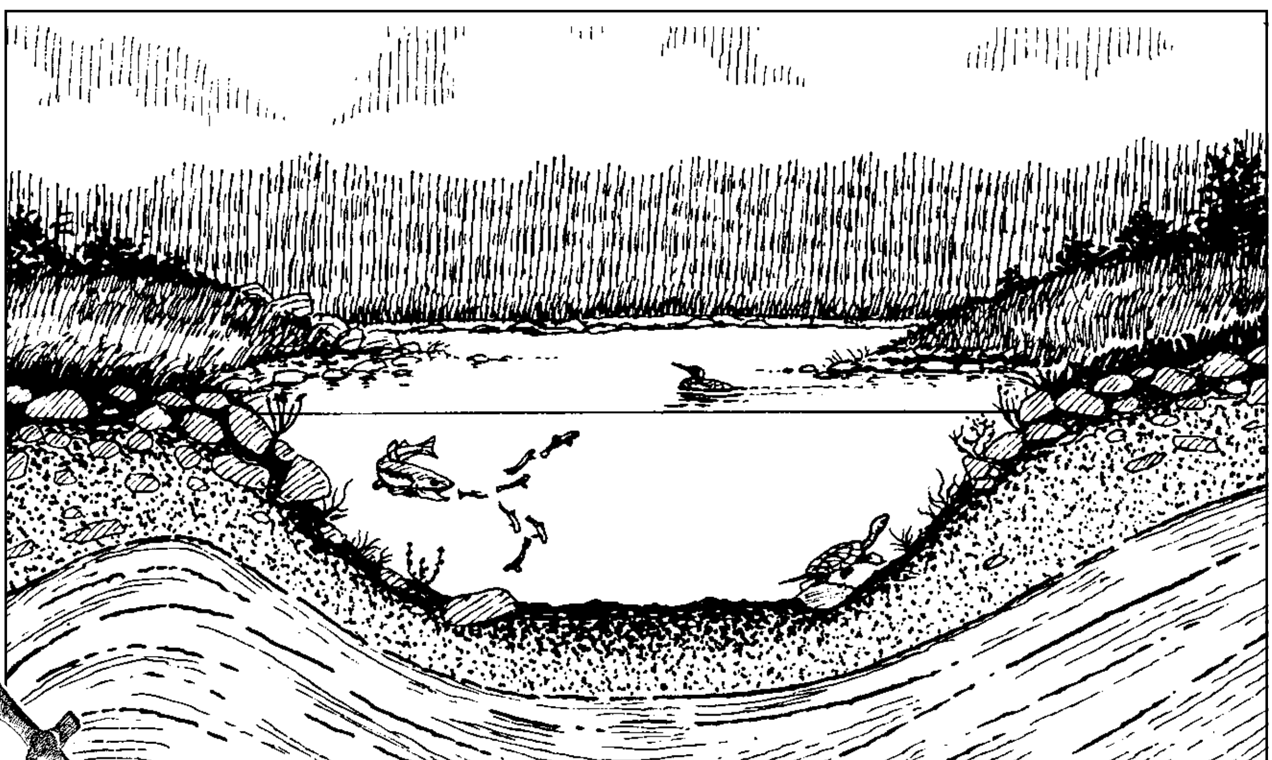
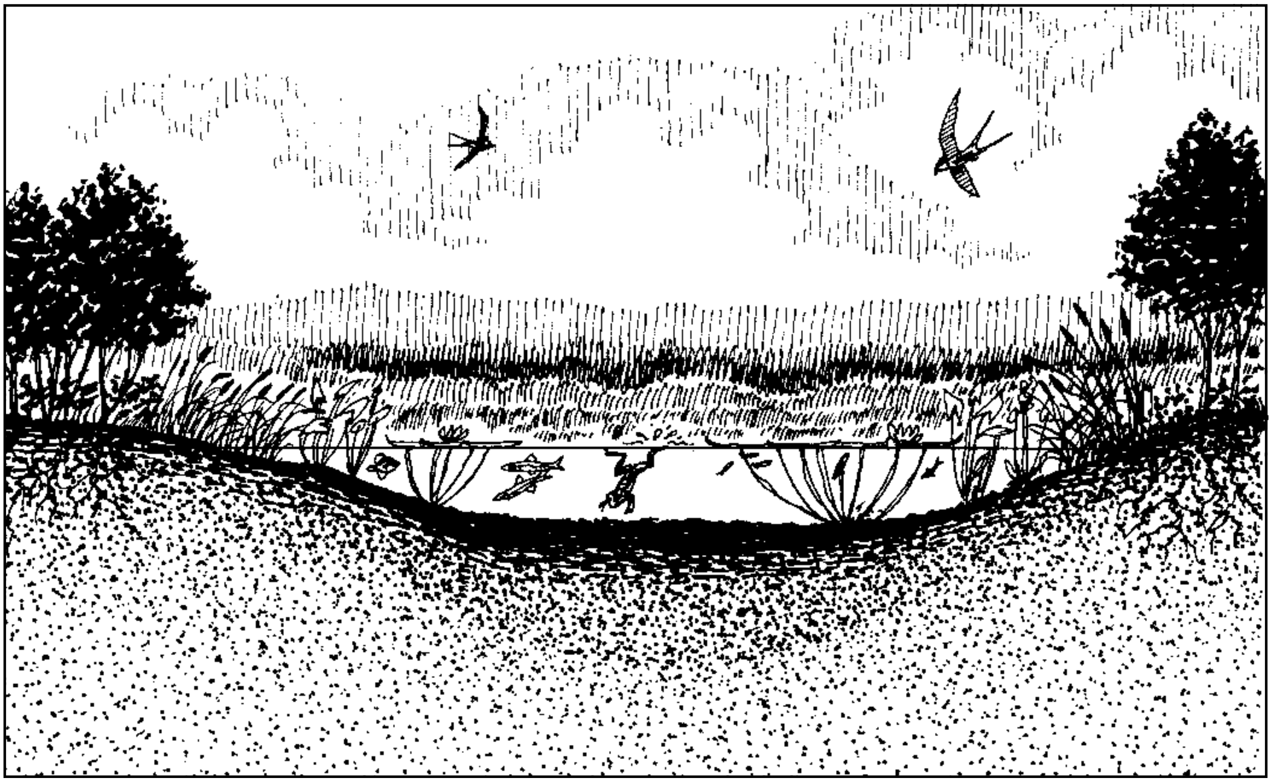
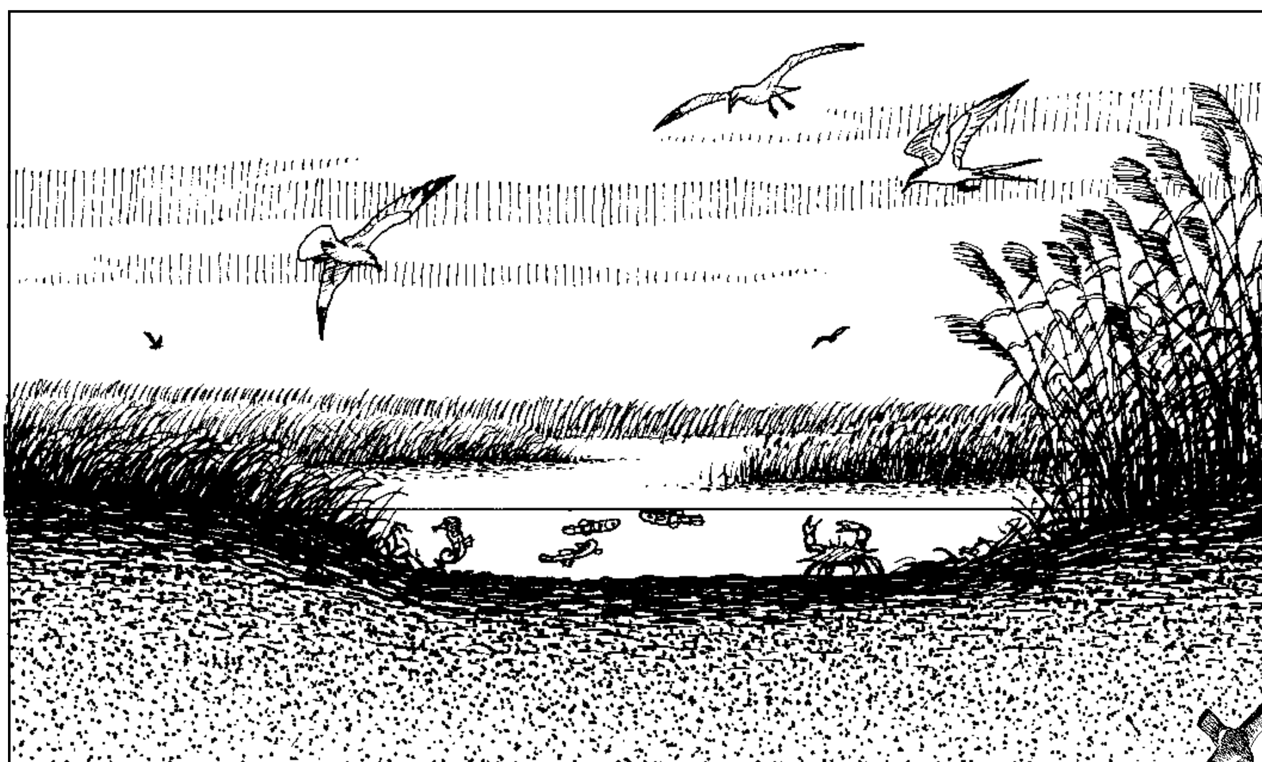


FIGURE 4C

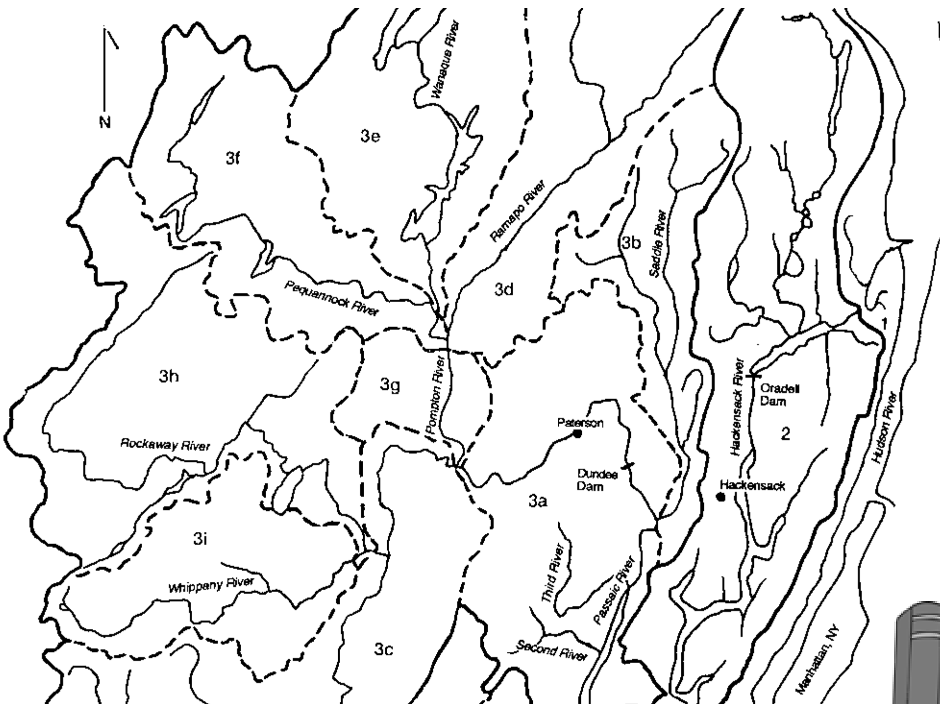
FRESHWATER MARSH HABITAT



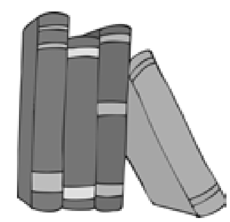
SALTWATER MARSH HABITAT



WHERE IN THE WORLD?



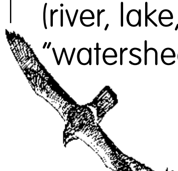
BACKGROUND INFORMATION



Most natural river systems follow the same distinct pattern of flow from small streams to larger rivers, which, if traced far enough, drain into an ocean or sea. They begin at the headwaters, usually a natural spring, run-off from snowmelt, or a rain-fed pond. As these small fresh water streams merge with other streams, they produce the wider, deeper channel of a river. In most cases, these rivers will connect to estuaries influenced by ocean tides.

A river's channel is determined by many factors, including natural landforms, rock strata underlying the surface of the earth, and volume of water flow. All of the land area that drains into a specific body of water (river, lake, stream, ocean) is called its "watershed."

Like most urban waterways, the river systems of the Newark Bay Complex have provided a means for commercial transportation and growth in the area. The rivers have been dammed, channeled and filled. They are the repositories for unwanted products and by-products. They also provide a place for people to enjoy various forms of recreation like fishing, boating, bird watching, and other nature-related activities. Since rivers are not confined to one community or one demographic region, all who live in the watershed play an important role. The consumption and disposal of products as well as the use of the land determine the health of the river system.



LEVEL
4 to 8

LENGTH
3 to 4 class periods

MATERIALS

One for each pair of students:

- o Town map that shows streets and waterways
- o The Newark Bay Complex (Figure 5A)
- o Watersheds of Northern New Jersey (Figure 5B)
- o Tidal Marshes of the Newark Bay Complex (Figure 5C)
- o Map of New Jersey
- o Discovery Sheets #3, #4, #5, and #6

OVERVIEW

Students discover their sense of place as it relates to local waterways and watersheds.

OBJECTIVES

Students will:

- Interpret local and regional maps;
- Demonstrate an understanding of the factors that affect their watershed;
- Describe the effects of population density on a waterway.

ADVISORY LINK

The Fish Consumption Advisories covers the tidal portions of the Newark Bay Complex, but the health of the estuary ecosystem is largely dependent on the quality of the entire watershed.

KEYWORDS

brackish	ground truth	salt marsh
cartographer	headwaters	tidal marsh
channel	landform	tributary
drainage basin	non-point source pollution	watershed
estuary	point source pollution	waterway
freshwater marsh	river mouth	

STUDENT PREREQUISITES

Practice in map reading
An understanding of basic river system dynamics
An understanding of the definition of watershed
An understanding of point source pollution and non-point source pollution

PROCESS SKILLS

interpreting	formulating
communicating	hypotheses
comparing	analyzing
estimating	synthesizing

PLANNING

- Obtain a copy of each of the maps listed under materials.
  - New Jersey road maps - the New Jersey Department of Commerce, Division of Tourism, PO Box 826, 20 W. State Street, Trenton, NJ 08625 (609) 292-2470.
  - Topographic maps - sports/camping stores, from the New Jersey Atlas & Gazetteer by DeLorme or by ordering through the NJ Department of Environmental Protection (DEP) Publications Catalog: Map and Publications Sales, NJDEP, PO Box 417, Trenton, NJ 08625-0417 (609) 777-1038.
- If necessary, create the town map by copying the portion that includes your school and the closest waterway. Enlarge (or reduce) it to an 8 ½ x 11-inch size.
- Make enough copies of the other maps for each pair of students or small group. (Optional: Laminate each map or cover with clear contact paper for multiple use.)
- Make copies of Discovery Sheets #3 through #6 for each pair of students or small group.

PROCEDURE
SETTING THE STAGE

Ask the students to think of a river or stream they have seen or visited. Discuss what they did there and how the waterway looked. Create a list of the types of activities for which people used the waterway.

THE ACTION

Divide the class into pairs or small groups. Distribute the appropriate discovery sheets and maps in sequence.

CLOSING DISCUSSION

*Note: Read through the questions on the Discovery Sheets before using the following questions in discussion.

Discovery Sheet #3 – A Tour through Your Town (Town map)

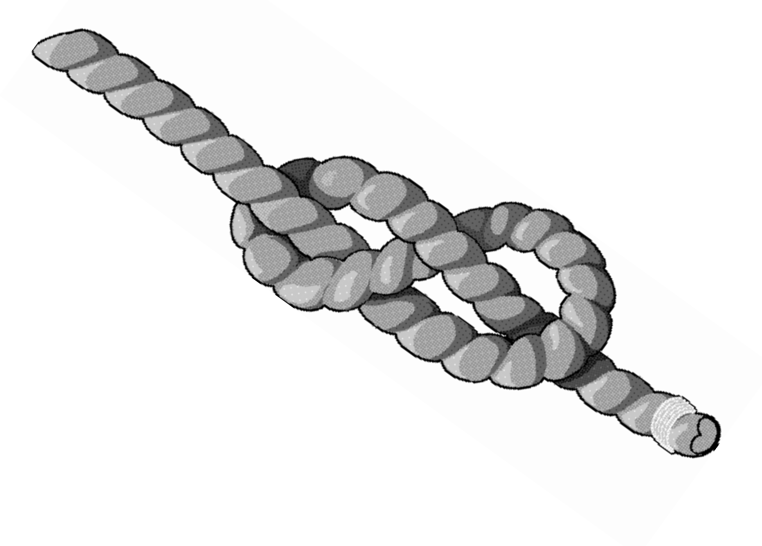
1. List the types of information found on this map [*streets, parks, building complexes, etc.*].
2. Have each group share their directions from the school to the closest waterway with the class. Have the students decide which directions are the most complete and why.
3. Discuss how the students' directions can be verified. [*They can be verified by following the directions, confirming the directions with someone who has followed them, or looking at aerial photographs.*] Introduce the phrase "ground truth."
4. If possible, ground truth the directions to confirm map interpretations. If the waterway is not visible, look for evidence of a streambed, ask local authorities about it, or interview residents. Discuss how cartographers ground truth the maps they make.
5. Ask whether any of the students have visited the waterway. List the types of land uses they saw near the waterway, i.e. parking lot, marina, restaurant, park, roads, bridges, etc. Introduce non-point source pollution or "people pollution" and how each of these land uses contributes to water quality.

Discovery Sheet #4 – The Newark Bay Complex (Figure 5A)

1. If you were to take a boat from the river's headwaters to its mouth, what physical changes would you observe? [*The river starts out small. Other rivers join it. The river gets larger. The river may get dammed.*]
2. Starting at the headwaters of one of the major rivers, describe how the research you did on town population numbers compare. What reasons could explain the differences? [*Higher population numbers in the urban areas coincide the portion of the river that was navigable by ship and therefore more easily settled. Smaller population numbers denote more rural areas.*]
3. Based on your understanding of land use and town populations, what do you think happens to the water quality as the water flows from headwaters to river mouth? Justify your answer.

Discovery Sheet #5 – Tidal Marshes of the Newark Bay Complex (Figure 5B)

1. Ask whether any of the students have visited a tidal marsh. Describe the purpose of the visit, what the marsh looked like, the types of plants and/or animals seen, and any evidence of human activity.
2. Introduce and discuss the term brackish.
3. Compare the qualities of a tidal marsh to those of a riverside park in a city or town. Where would there more likely be ball fields, jogging trails, picnic pavilions, etc? Why? [*tidal marsh – muddy, wet, affected by the tides twice a day; park – higher land, usually grassy*]
4. What reasons could explain why the Meadowlands Sports Complex, Newark International Airport, Port Elizabeth, and Port Newark were located where they were? [*Proximity to New York City and the northern New Jersey populations, built where there was space left*]
5. What construction challenges would be encountered when building in a tidal marsh zone? [*Builders would have to deal with unstable land; they would have to use fill; and they would have to develop ways to keep the tides from affecting the development site.*]



Discovery Sheet #6 – Watersheds of Northern New Jersey (Figure 5C)

1. Look at a map of New Jersey. What is the boundary between New Jersey and Pennsylvania? [*the Delaware River, which is a natural boundary*] Trace the Garden State Parkway to the New York Thruway (Route 87). How would you know that you have crossed from New Jersey to New York? [*state line sign, which signifies a political boundary*].
2. Compare the Watersheds of Northern New Jersey (Figure 5C) and the Newark Bay Complex map (Figure 5A). Which map shows the natural landforms as boundaries and which map relies more on human made boundaries? [*Watersheds use natural landforms as boundaries (Figure 5C), people create county and state lines (Figure 5A).*]
3. What are the advantages and disadvantages to viewing the land in each of these manners? [*Looking at the land in view of watersheds connects people and habitats within a regional natural system that forces a dialogue between planners from nearby towns and states. Looking at the land using political boundaries is a traditional view, might make planning more manageable.*]
4. Complete the following in terms of how the action will affect the entire watershed:
   - A new condominium complex is built near the Pequannock River...
   - A series of new roads were built through a forested area of the Highlands...
   - A ship docking in Port Elizabeth leaked crude oil into the Newark Bay...

ASSESSMENT STRATEGIES

Have the students:

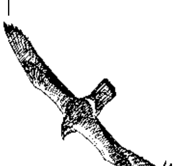
❏ Develop critique criteria for a verbal presentation that answers the following question: How do land use practices in northern New Jersey affect the quality of water in the Newark Bay Complex? Have the students grade each other on content, organization of presentation, and presentation style.

STAYING INVOLVED

Invite a local organization that is doing water quality monitoring to the classroom. Have the students find out how they can participate in this activity.

Organize a stream walk and clean-up. (See Organizations to Contact - Appendix D)

Do storm drain stenciling to educate the neighborhood about the significance of keeping pollutants out of the storm drain system. Visit the following websites to learn more about this activity: (http://www.state.nj.us/dep/watershedmgt/stenciling4web.htm) or (http://www.cleanoceanaction.org/Stenciling/StormDrains.html)



EXTENSIONS

- Research and draw a small section of the river (divide the river's total length or town length by the number of students in your class). Include the structures built by humans as well as the wild open spaces. Connect the sections and use as a hallway display.

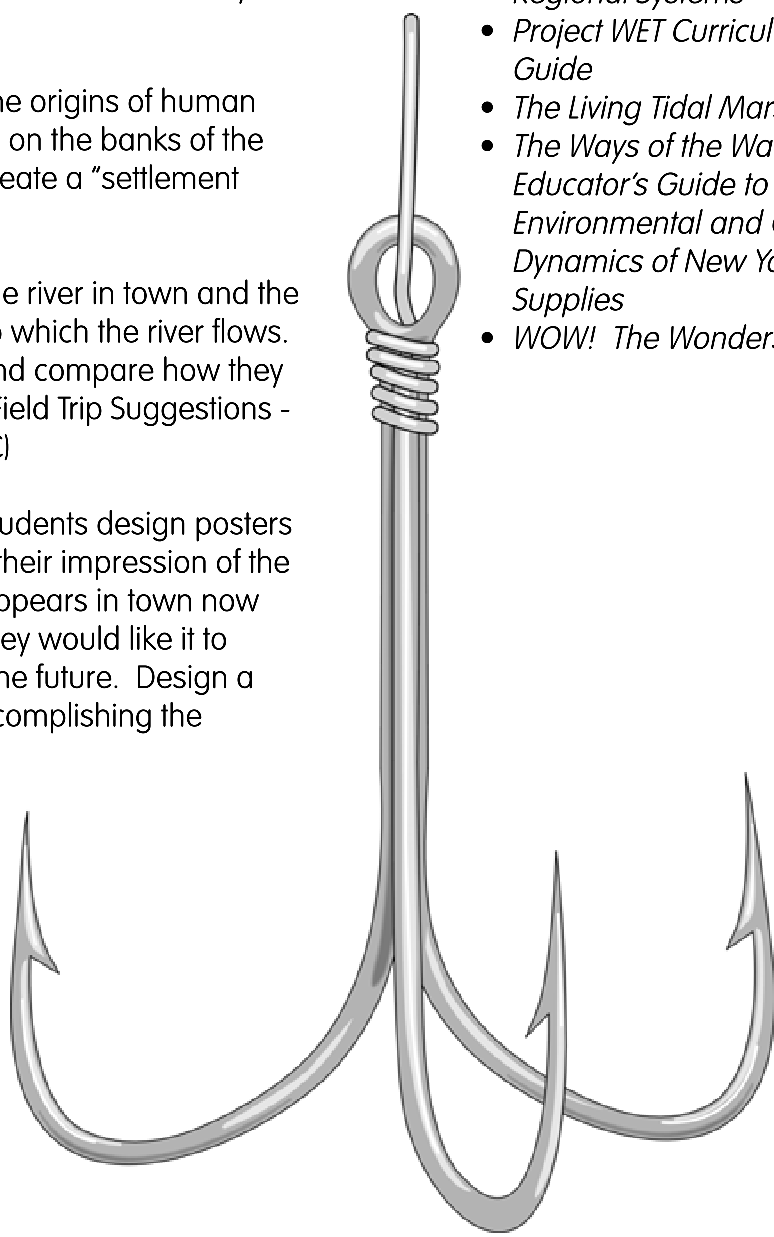
- Research the origins of human settlements on the banks of the river and create a "settlement timeline."

- Visit both the river in town and the estuary into which the river flows. Describe and compare how they look. (See Field Trip Suggestions - Appendix C)

- Have the students design posters that reflect their impression of the river as it appears in town now and how they would like it to appear in the future. Design a plan for accomplishing the change.

RELATED EDUCATION RESOURCES

- *Bridges to the Natural World: A Natural History Guide for Teachers of Grades Pre-K to Six*
- *New Jersey WATERS: A Watershed Approach to Teaching the Ecology of Regional Systems*
- *Project WET Curriculum and Activity Guide*
- *The Living Tidal Marsh*
- *The Ways of the Watersheds: An Educator's Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies*
- *WOW! The Wonders of Wetlands*



REFERENCE

Baldi, Bruce. "The Hackensack Meadows: A Natural and Unnatural History." American Littoral Society, Highlands, NJ. 1981.

A TOUR THROUGH YOUR TOWN (Town map)

Discovery Sheet #3

Name(s): ____

Date: ______________________

1. Locate the following places on your town (or city's) map and circle each with pencil or marker.

   - Your school (or street)

   - The closest stream, river or waterway to your school. What is the name of this waterway?

2. Use a highlighting marker to trace the course of the waterway through your town. List the names of the roads that cross the waterway and landmarks that are near the waterway.

3. Write directions from your school to the waterway.

4. Trace the length of the waterway to determine if it is a tributary to a larger river. If so, name the larger river into which it flows.

A TOUR THROUGH THE NEWARK BAY COMPLEX

Discovery Sheet #4

Name(s): ____

Date: _______________________

On the Newark Bay Complex map (Figure 5A)

1. Color all the waterways and water bodies on the map with blue crayon. If needed, check this against the map of New Jersey.

2. Color the waters of the Newark Bay Complex with a red crayon. (The Newark Bay Complex includes all the water south of the Dundee Dam on the Passaic River, south of the Oradell Dam on the Hackensack River, the Newark Bay, the Kill Van Kull, the Arthur Kill, a small portion of the Elizabeth River, and the Rahway River up to where it splits.)

3. Locate and mark your town on the Newark Bay Complex map.

4. Name the largest river closest to your town.

5. Locate this river on a New Jersey map. Trace the entire length of the river from its headwaters (the beginning) to the Newark Bay. Estimate how much of this length is <u>in</u> the Newark Bay Complex.

6. Compare your town map or the New Jersey map to the Newark Bay Complex map. Is your local waterway a tributary of the river you named in Question #4?

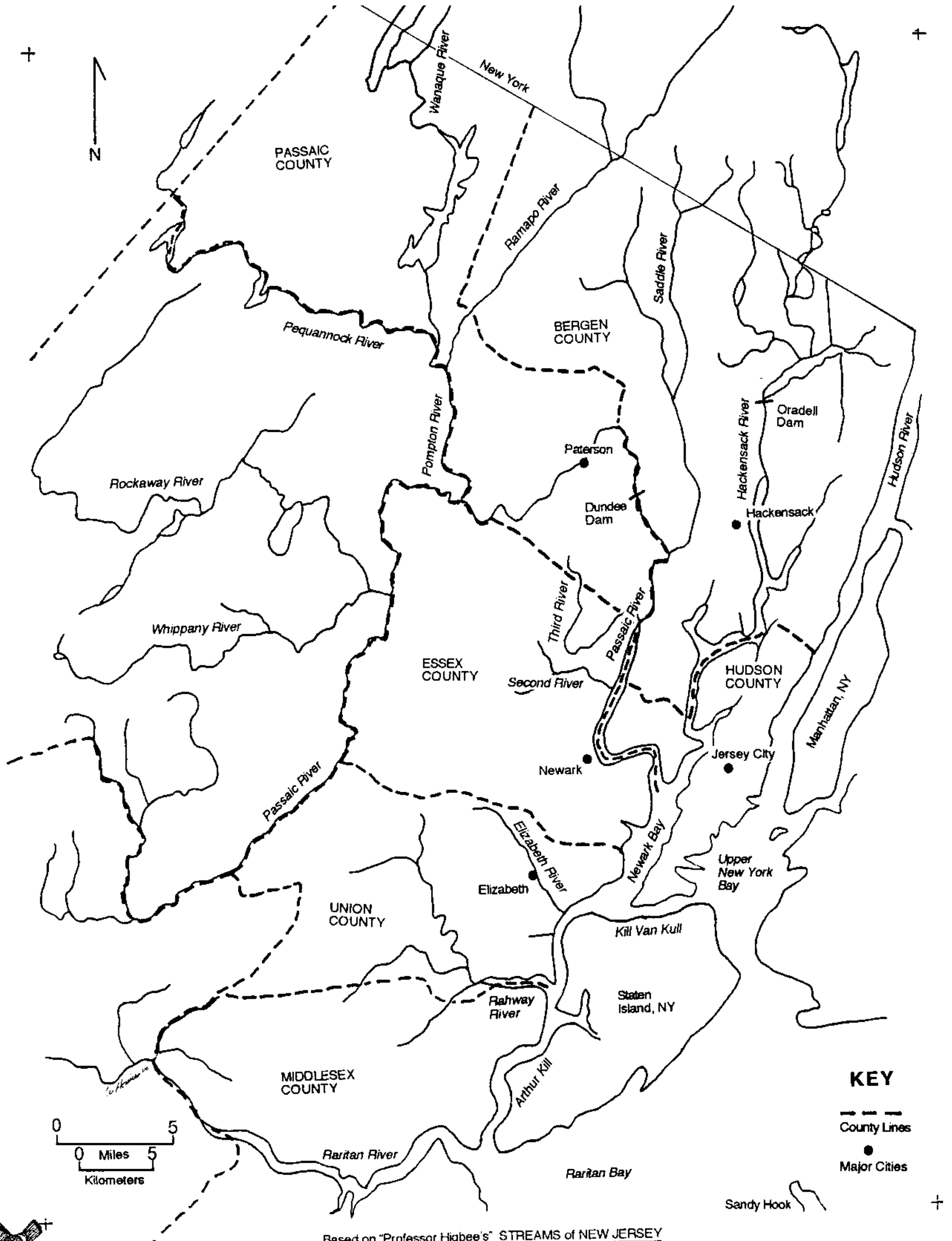
   - *If yes, list the name changes that the waterway takes as it flows from your town to the larger river.*

   - *If no, list the possible reasons why your local waterway does not join the larger river.*

7. Identify and list major towns along the larger river. Begin at the headwaters and end at the mouth (where it empties into another river or bay). Use the population key on a New Jersey map to list each town's population range.

Figure 5A

A TOUR THROUGH THE NEWARK BAY COMPLEX



Based on "Professor Higbee's" STREAMS of NEW JERSEY

A LOOK AT THE TIDAL MARSHES (Figure 5B)

Discovery Sheet #5

Name(s): ____

Date: ________________________

1. What type of water is in the ocean?
   Color the following yellow: Atlantic Ocean, Raritan Bay, Upper New York Harbor, Hudson River, Arthur Kill, Kill Van Kull, Newark Bay and the length of both the Hackensack and Passaic Rivers from Newark Bay up to where the symbol for "tidal marsh" stops.

2. What type of water comes from mountain streams?
   Color the following blue: Passaic and Hackensack Rivers from headwaters to Newark Bay, Whippany River, Rockaway River, Pequannock River, Wanaque River, Ramapo River, Pompton River, Saddle River, Third River, Second River, Elizabeth River, Rahway River from headwaters to the Arthur Kill.

3. If you visited a place on the map where the two colors overlap, describe the type of water you would find.

4. Create a map key that identifies the three types of waters.

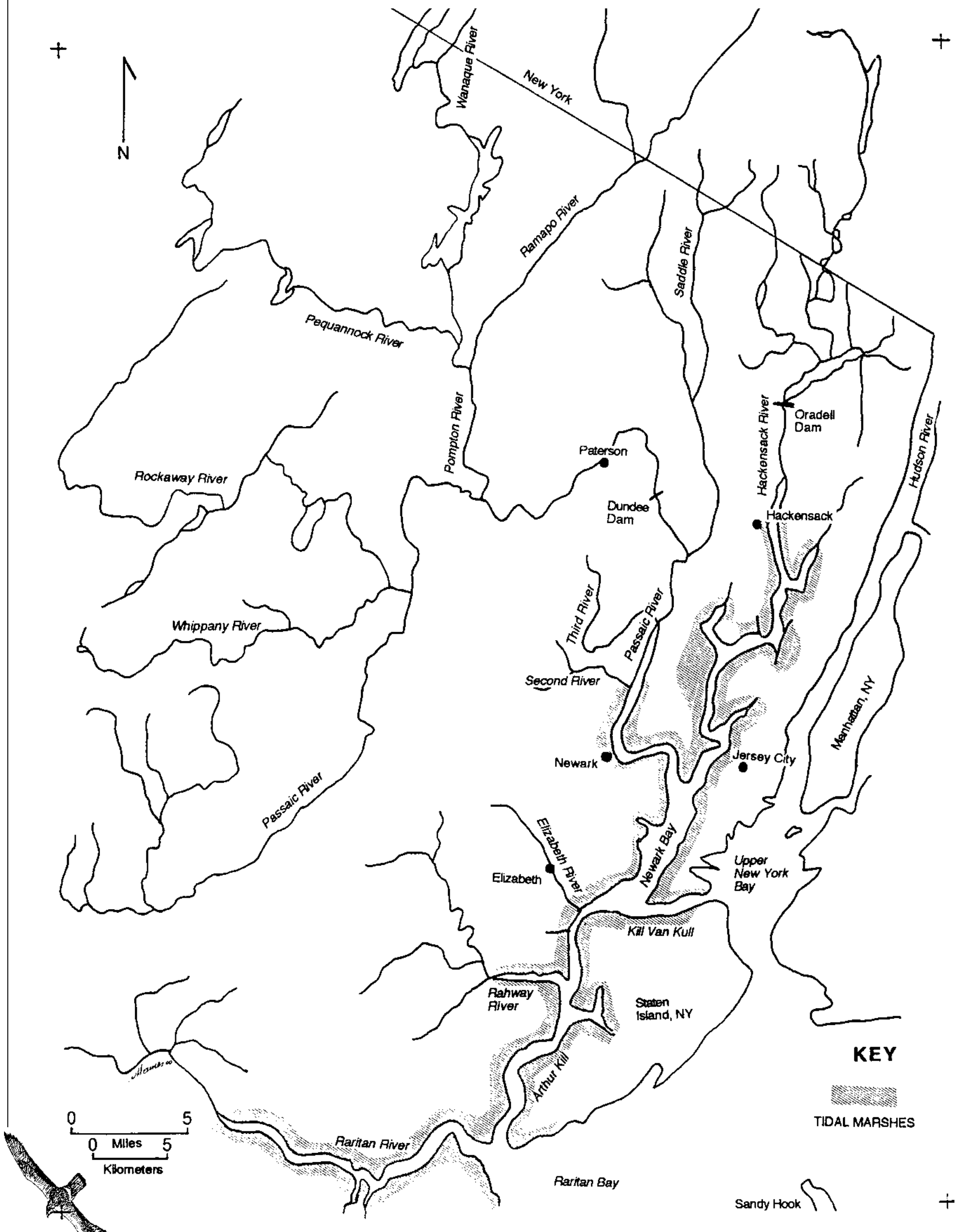
5. Using other resources (first hand experience, natural history guides, the library, etc.), list the qualities of a tidal marsh.

6. Estimate how many miles of tidal marsh exist in the Newark Bay Complex, from the Raritan Bay northward.

7. Use a map of New Jersey to locate and mark the following on your map:
   - Meadowlands Sports Complex
   - Newark Airport
   - Port Elizabeth
   - Port Newark

Figure 5B

A LOOK AT THE TIDAL MARSHES



A TOUR THROUGH THE WATERSHEDS of Northern New Jersey (Figure 5C)

Discovery Sheet #6

Name(s): ____

Date: ____________________

1. Define "watershed."

2. Locate and mark your town on the Watersheds of Northern New Jersey map (Figure 5C).

3. Outline each of the watersheds listed in the key (#'s 1 to 4) in a different color. Add these colors to the map's key.

4. Color each of the subwatersheds a different color. Add these to the map's key.

5. Where on the map is the area of higher elevation? How do you know this?

6. What landforms would create the higher elevation?

7. What creates the dividing lines between watersheds and between subwatersheds? How could you check your answer?

8. Compare the watershed map to the Newark Bay Complex map (Figure 5A). What are the similarities? What are the differences?

9. Using the town map and the Watersheds of Northern New Jersey map, write your watershed address. (Example: I live in the Saddle River subwatershed and the Passaic Watershed.)

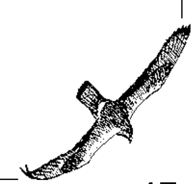
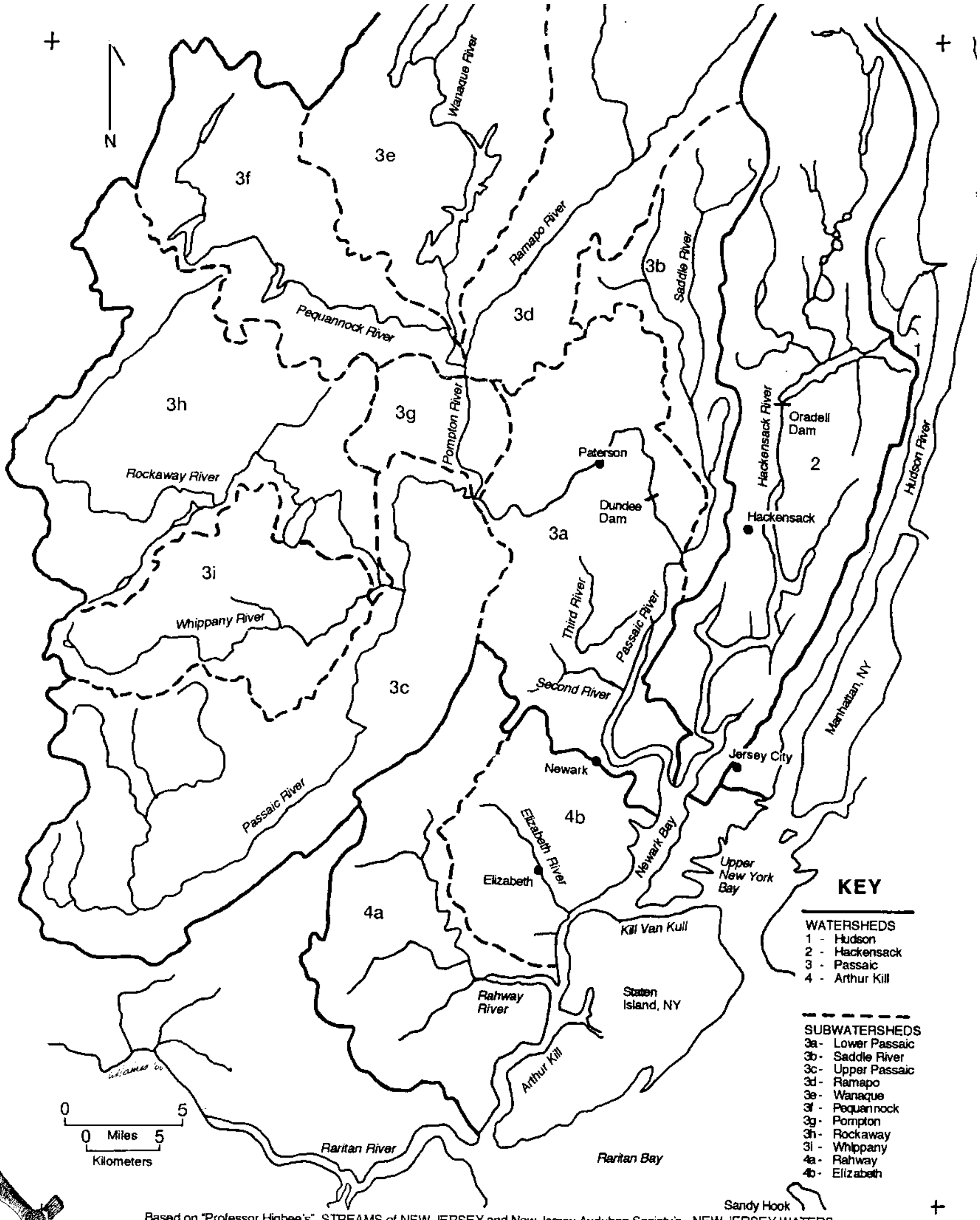


Figure 5C

A TOUR THROUGH THE WATERSHEDS
of Northern New Jersey



Based on "Professor Higbee's" STREAMS of NEW JERSEY and New Jersey Audubon Society's - NEW JERSEY WATERS